

**EVALUATION OF MODIFIED
WORK ZONE TRAFFIC CONTROL
DEVICES AT BUSINESS ACCESSES**

Final Report

State Planning and Research Project #311



Oregon Department of Transportation

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by

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16. Abstract Modified work zone traffic control devices at business accesses were evaluated on two Oregon Department of Transportation (ODOT) projects in 1999 and 2000. In Sweet Home, Oregon, on the Sweet-Home WCL - Foster Dam Rd. Section project, blue "Temporary Business Access" signs were used at business accesses during driveway, curb, gutter and sidewalk construction. In Pleasant Hill, Oregon, on the Goshen - Pheasant Lane Section project, blue Temporary Business Access signs and blue tubular markers were used to delineate accesses to business during construction. The analysis of traffic count data taken at business accesses in Sweet Home before and during construction yielded inconclusive results. The effectiveness of the Temporary Business Access signs could not be determined from the results of the traffic count data. However, results of telephone surveys of motorists and businesses in Sweet Home demonstrated the usefulness of the Temporary Business Access signs. Twelve of 14 businesses said the presence of the Temporary Business Access signs helped customers locate their driveways. Additionally, 242 of 371 motorists surveyed noticed the signs, and 83% (171) indicated the signs helped them locate the business access. The traffic count data for four business sites in Pleasant Hill provided some evidence that businesses were not significantly impacted when blue tubular markers and Temporary Business Access signs were used during periods of construction activities at their accesses. The seven-day counts that were recorded between April 1999 and October 2000 demonstrated little difference between regular traffic volumes and construction traffic volumes with blue markers and signs. In the survey of 12 businesses in Pleasant Hill that had blue tubular markers and signs placed at their accesses, 6 of them said the markers and signs helped customers locate the driveways. 381 motorists who live along the OR Route 58 corridor were surveyed; 62% (237) of them had noticed the blue tubular markers and signs. Of the 62% who noticed the blue tubular markers and signs, 78% (185) felt these devices helped them locate the driveways to the businesses. Based on the results of the research, the continued use of blue tubular markers and business access signs is recommended.					
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EVALUATION OF MODIFIED WORK ZONE TRAFFIC CONTROL DEVICES AT BUSINESS ACCESSES

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1.0 INTRODUCTION

1.1 PROBLEM STATEMENT

Maintaining customer attraction and access to businesses during roadway construction projects is a common problem. The difficulty is exacerbated when the drivers' task of locating a business driveway is hampered by the presence of work zone traffic control devices.

Long rows of orange tubular markers/barrels are used frequently for lane closures, detours, shoulder work and curb construction. Although the orange tubular markers provide sufficient guidance to through-traffic, they create visual clutter for the driver trying to locate a business access. The clutter may lead to confusion, frustration and discouragement to visit the establishment. In past Oregon Department of Transportation (ODOT) projects, motorist surveys have cited the difficulty in finding business entrances during construction as a key problem. Business owners are often apprehensive about the potential loss of revenue due to construction.

Although construction-induced traffic congestion may be a major contributor to the problem, providing guidance for drivers to easily access the businesses could mitigate adverse impacts. Different traffic control devices had been tried on earlier ODOT projects to aid traffic movement into and out of businesses, but their effectiveness had not been objectively evaluated. Therefore, this research project was developed to evaluate two non-standard traffic control devices used to assist in locating business accesses. The devices included blue tubular markers used only at access points and signs that read "Temporary Business Access."

1.2 RESEARCH OBJECTIVES

The overall goal of the research was to find better methods to mitigate the impact of highway construction on businesses. Specific objectives included:

- To determine if the use of non-conventional blue tubular markers and Temporary Business Access signs can significantly alter customer use of businesses located on roadway construction projects.
- To determine if public and business owner perception of project safety and access are improved by the use of these non-conventional traffic control devices.

1.3 METHODOLOGY

The following tasks were undertaken to accomplish the research objectives:

1. A literature review to determine what practices (if any) have been employed by other states to mitigate the construction impacts to businesses.

2. Identification of construction projects where blue tubular markers and Temporary Business Access signs could be used and evaluated.
3. A quantitative evaluation of customer traffic prior to, and during, construction. Traffic counts were made at business access points to monitor customer use before and during construction. The original intent was to obtain traffic counts “during construction” under two conditions: 1) using only standard orange tubular markers, and 2) using business access signage and the blue tubular markers at driveways. However, that strategy was modified because it would have been difficult to ensure consistent test environments for both the standard orange tubular markers and the other devices. Therefore, the experiment design was changed to compare traffic before construction with traffic when the blue tubular markers and signs were in place during construction.
4. A survey of the business owners affected by each selected construction project, to determine their perceptions on the impact to their business and the effectiveness of the blue tubular markers and Temporary Business Access signs. Additionally, this task also included a survey of motorists to determine their views on the effectiveness of these devices.
5. Conclusions and Recommendations.

2.0 LITERATURE REVIEW

Previous research has focused primarily on determining the impact to businesses because of a highway construction project. None of the prior studies specifically evaluated methods or use of traffic control devices to improve accessibility to businesses during highway construction. The following includes a summary of past research as well as prior use of non-standard work zone traffic control devices at business accesses on Oregon highway projects.

2.1 HIGHWAY WIDENING IMPACTS TO BUSINESSES

Wildenthal and Buffington (1996) looked at the impacts to businesses in Caldwell, Texas during and after a highway widening project (Texas Highway 21) that occurred from January 1991 to July 1993. The authors reviewed a broad range of possible effects attributed to the construction including customer fluctuation, parking, net profits, and property values. A primary source of information was a survey of the managers of businesses alongside the highway. Traffic data (counts and classifications) were also collected, and property appraisal records of abutting businesses were examined. Through survey data, the authors found that two-thirds of the business managers (34 of 54 respondents) reported decreases in customers during construction. Further, for a two-year period (1990-1992) during construction, the combined sales of the 23 reporting businesses decreased by 5%. Alternatively, Wildenthal and Buffington noted that some of the businesses surveyed actually had increased sales during the construction period. This was attributed to either additional patronage by construction workers or greater accessibility to that particular business because of improvements made by the construction project.

In reviewing property values, the authors found that the property values of businesses along the highway decreased over a two-year period. They attributed the decrease to depreciation of the businesses' physical structures, because at the same time, appraised land values increased.

Regarding the construction impact on traffic, Wildenthal and Buffington reported traffic volumes (based on a three day count) decreased from 6,690 vehicles per day in 1991 to 5,583 vehicles per day in 1992. In 1993, the volume increased to 5,947 vehicles per day. They also noted that travel time through Caldwell on Texas Highway 21 increased by 8.4% from 1990 to 1991.

2.2 EFFECTS OF FREEWAY RECONSTRUCTION ON BUSINESSES

De Solminihac and Harrison (1993) explored the impact of the construction of the Southwest Freeway (U.S. Route 59) in Houston, Texas on businesses along the freeway frontage roads. Construction on this segment occurred from August 1989 to December 1992. The authors, using aggregated sales data by retail category, determined that "four retail groups – general merchandising, food stores, automotive outlets and home furnishings had been adversely affected by the construction on U.S. 59."

In addition to sales analysis, De Solminihac and Harrison surveyed 118 of the 337 businesses along the corridor, and received responses from 74. The survey results showed that about 77% of the respondents reported their sales had decreased by at least 10% during the construction period, and 40% indicated their sales had decreased by over 20%. When asked what the highway agency (Texas Department of Transportation) had done to make things easier for the business during construction, 3% said that the agency had put up signs for the business. Alternatively, when the businesses were asked what actions they had taken to mitigate construction impacts, 11% said they had erected signs for their entrances and exits.

2.3 MOTORIST COMPREHENSION OF SIGNING IN WORK ZONES

Ogden and others (1990) addressed motorists' understanding of work zone signing that was used on the reconstruction of Farm-to-Market (FM) 1960, a major arterial highway in Houston, Texas. The authors reported the results of surveys of 205 people that were conducted at two separate locations near FM 1960. The survey included a series of photos of signs and scenes from the reconstruction project, with corresponding questions. The survey questionnaire asked about: (1) work zone signs and other traffic control devices; (2) work zone signs on the FM 1960 project; and (3) respondents' opinions about various aspects of the reconstruction project.

One category of questions asked about locating and accessing destinations adjacent to FM 1960. Almost half of the respondents (49.5%) answered yes to the question: "Do you have trouble finding certain places you want to go because of construction?" This project had involved over 360 business driveways; some of the business owners adjacent to FM 1960 had placed directional signing indicating the location of the access drive to their business. The authors noted that the signs showed the business name, logo and a directional arrow. When surveyed, a majority of respondents (53.5%) favored the placement of these signs.

2.4 EFFECTS OF EXPRESSWAY RECONSTRUCTION ON BUSINESSES

Harrison and Waldman (1998) examined the impact of the reconstruction and expansion of the Dallas North Central Expressway on businesses along the freeway corridor. The authors analyzed the businesses' gross sales data (provided by the Texas State Comptroller) and surveyed affected businesses along the corridor at two different points in the construction cycle. The first survey was given to 149 affected businesses after completion of the first two sections of the expressway. Overall, the majority of respondents (63%) felt that though they were affected by the construction, there were significant improvements after the expressway frontage roads were complete.

The second series of surveys, given to 107 different businesses, was conducted during construction of the next two expressway sections. The survey instrument was modified to use more check boxes for answers, thus reducing the amount of subjective responses. The authors believed this improved the response rate (93%) and streamlined data analysis. Generally, they noted that responses were very favorable. Over 50% of the businesses gave a good or excellent rating for the way construction and traffic safety was handled. Harrison and Waldman noted however, that while the surveys were administered during the expressway construction, the

frontage roads serving the businesses had been completed. This suggests that a critical area for businesses is the portion of roadway that allows access to, and from the business.

In their analysis of the sales data, the authors concluded that “construction did not significantly affect business sales in the North Central Expressway corridor.” They suggest that “sales for the majority of businesses are more dependent on the overall level in the economy rather than specific construction projects” (*Harrison and Waldman 1998*).

2.5 OREGON’S PREVIOUS USE OF TRAFFIC CONTROL DEVICES TO IMPROVE ACCESS TO BUSINESSES

In 1999, directional signs for businesses were used on the N. 102nd Ave. - N.E. 122nd Ave. Section project which involved reconstructing a 1.6 km section of Sandy Blvd., a major urban arterial in Portland. On this project, ODOT installed directional signs showing the entrances to individual business parking lots located adjacent to Sandy Blvd. The signs also showed the names of the businesses served by the lots.

In 1998, modified tubular markers and blue “Temporary Business Access” signs were used on an ODOT project in Albany, Oregon to designate business accesses. The project, Pacific Blvd. & 9th Ave. Couplet Section, involved the reconstruction of two major arterials connecting the City of Albany and Interstate 5. On this project, standard orange tubular markers were modified by covering about two-thirds of their surface with blue reflective sheeting.

2.6 SUMMARY

It is apparent from the review of previous research that there has been very limited study of any special traffic control devices intended to improve accessibility for businesses. The body of research has focused on determining how businesses are impacted by construction. Usage of modified tubular markers and signs in Oregon indicated potential for further development and application. However, on these two prior occasions, no objective evaluation of the devices was conducted to determine their effectiveness. Since their future use appeared to be warranted, ODOT sought to fully evaluate the devices prior to a long-term commitment to their use.

In the next section, the modified traffic control devices are described, followed by discussion of the project locations.

3.0 RESEARCH DESIGN

3.1 DESCRIPTION OF MODIFIED WORK ZONE TRAFFIC CONTROL DEVICE

Two non-standard work zone traffic control devices were evaluated. Figure 3.1 shows the devices, a blue sign designating the access for a business and a blue tubular marker.

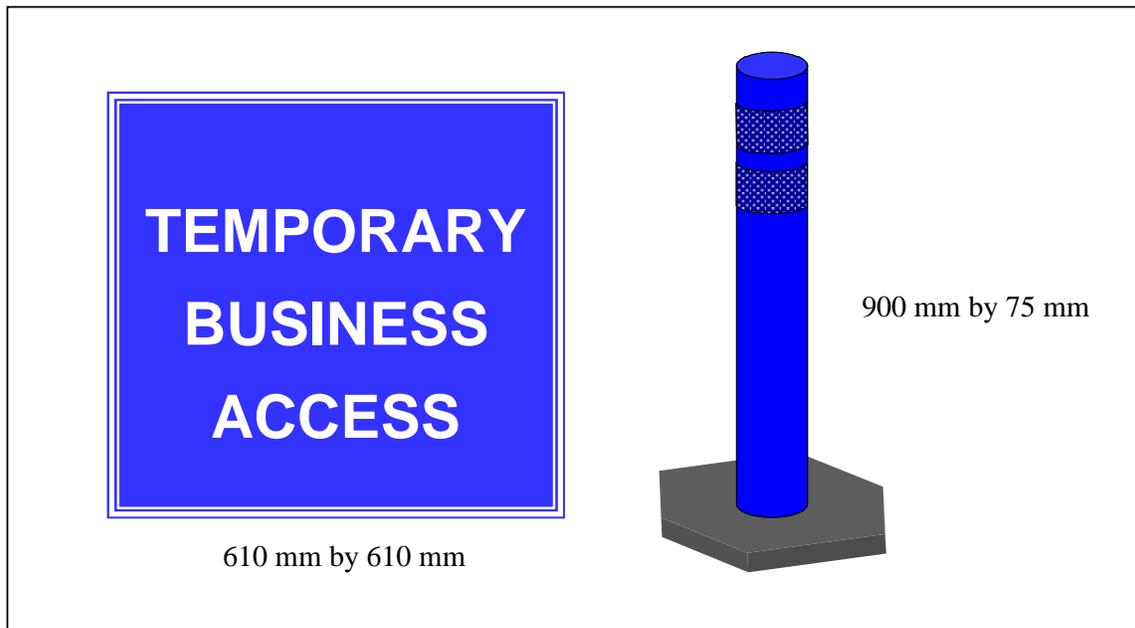


Figure 3.1: Modified Work Zone Traffic Control Devices Used at Business Accesses

The blue tubular markers and signs were provided by a local distributor, Traffic Safety Supply Co. in Portland, Oregon. Initially, there was some concern about finding a source for the blue tubular markers since these devices were not a standard item used in highway construction. Traffic Safety Supply Co. located Line Connection, a manufacturer of Dura-Post blue tubular markers. The Dura-Post urethane plastic tubular markers are typically surface-mounted directly to the pavement using an epoxy adhesive, and are frequently used to channelize or separate traffic. To meet ODOT's requirements for delineating business accesses, the tubular marker base was modified so that it could fit into the standard hexagonal base. Near the top of each marker, there are two bands of blue high intensity reflective sheeting. In 1999, the cost of the blue tubular marker with the hexagonal base was \$34.50 each.

The blue Temporary Business Access signs were specified as Type “B” 610 mm x 610 mm signs with 76 mm letters. When these devices were used together to delineate the driveways to a business during roadway construction, they were configured as shown in Figure 3.2.

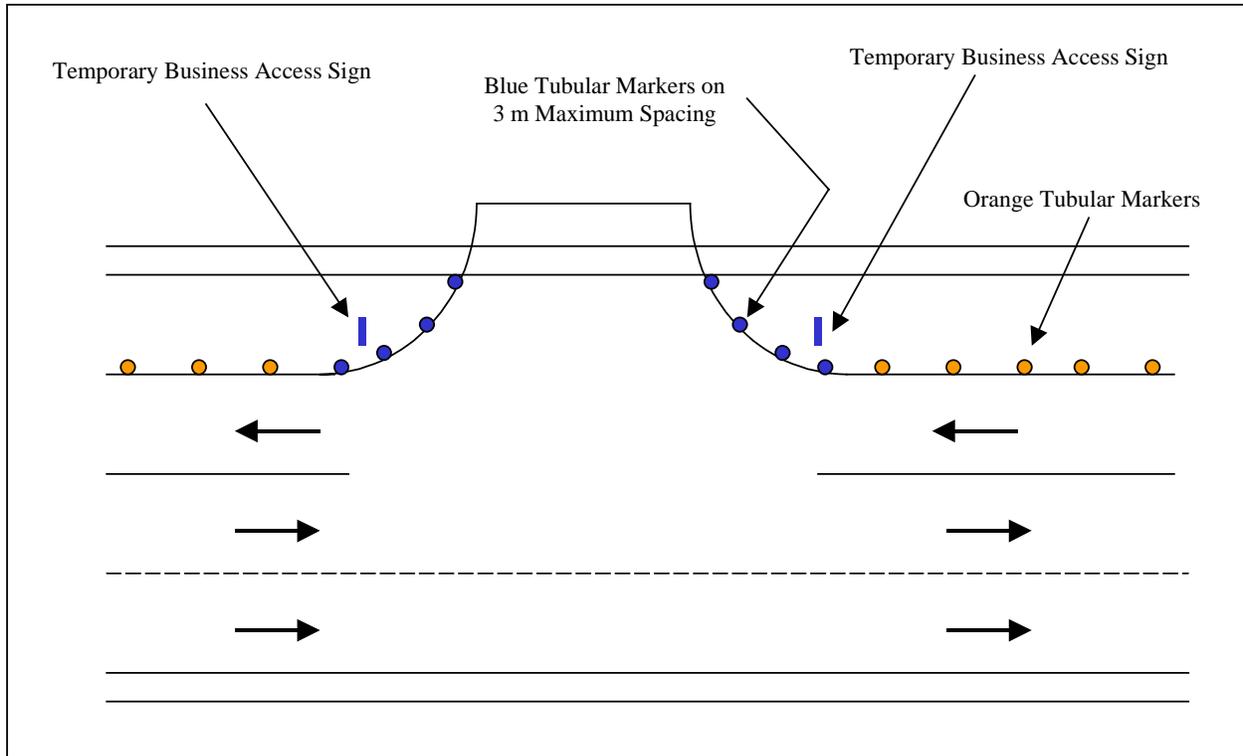


Figure 3.2: Typical Layout of Blue Tubular Markers and Signs at Business Access

3.2 PROJECT LOCATIONS

Two highway improvement projects in ODOT’s Region 2 were selected for research:

- Sweet Home WCL - Foster Dam Rd Section in Sweet Home; and
- Goshen - Pheasant Lane Section in Pleasant Hill.

Their locations are highlighted on ODOT’s Region 2 map shown in Figure 3.3. The site characteristics for each project are discussed below.



Figure 3.3: General Vicinity Map showing Project Locations

3.2.1 Sweet Home WCL - Foster Dam Rd. Section Site Characteristics

The Sweet Home WCL - Foster Dam Rd. Section project was a pavement preservation project on a 7.5 km section of U.S. Route 20, the Santiam Highway, through the City of Sweet Home. There are over 90 businesses along the highway section within the project limits in Sweet Home. Figure 3.4 shows the construction project location. Construction occurred on this project from May to September 1999.

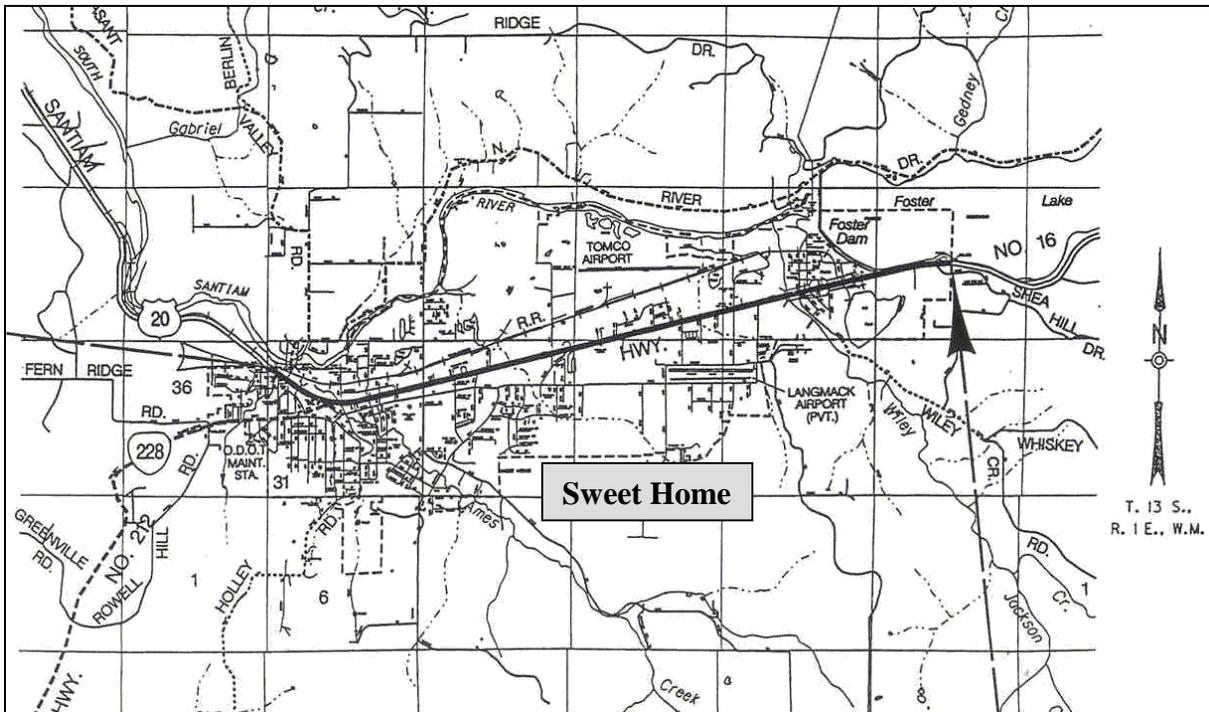


Figure 3.4: Location of Sweet Home WCL to Foster Dam Rd. Section

The project scope consisted of cold plane pavement removal and placement of new asphalt concrete pavement. Other construction work in the project included installing drainage pipe and appurtenances, signing, guardrail, and traffic signals. Additionally, a major portion of work involved construction of concrete curbs, sidewalks, driveways and traffic islands. The existing roadway through Sweet Home consisted of four lanes (two in each direction) with a center-turn refuge lane in the median (Figure 3.5).



Figure 3.5: U.S. Route 20 Looking East from 18th Avenue.

In the downtown portion of Sweet Home, from about 10th Avenue to 18th Avenue, there is a raised median and left hand turn movements are accomplished from left-turn refuge lanes at cross street intersections (Figure 3.6).



Figure 3.6: Downtown Sweet Home at 13th Avenue Looking West

Initially, both blue tubular markers and the Temporary Business Access signs were going to be used on this project. However, prior to contract letting in April 1999, the original scope of work was reduced from a full pavement reconstruction to a grind and inlay. Further, it was decided that the paving work in the downtown section would be accomplished at night to minimize disruption. By eliminating pavement reconstruction and paving at night, the work areas on the project would be shorter and the paving operations would move relatively quickly through the city. The more compact and dynamic work areas would require fewer orange tubular markers, so using blue tubular markers seemed impractical. As a result, a decision was made to use only the blue Temporary Business Access signs in Sweet Home to designate the access locations.

Although the change in project scope reduced the impact of paving work on businesses, there was still over 2,900 m² of driveway reconstruction that affected many of the businesses along the highway. In situations where business driveways were being reconstructed, ODOT wanted to test whether the Temporary Business Access signs would help motorists during construction directly affecting businesses.

3.2.2 Goshen - Pheasant Lane Section Site Characteristics

The Goshen - Pheasant Lane Section project consisted of reconstructing and widening a 9.8 km section of OR Route 58, the Willamette Highway. Part of the 9.8 km section included work in the community of Pleasant Hill. There are 22 businesses that are located adjacent to, or near the highway in the Pleasant Hill vicinity. Within the project limits, OR Route 58 is a two lane highway, with a continuous two-way left turn lane in the median between Ridgeway Road and Plaza Loop. Figure 3.7 shows the construction project location along OR Route 58.

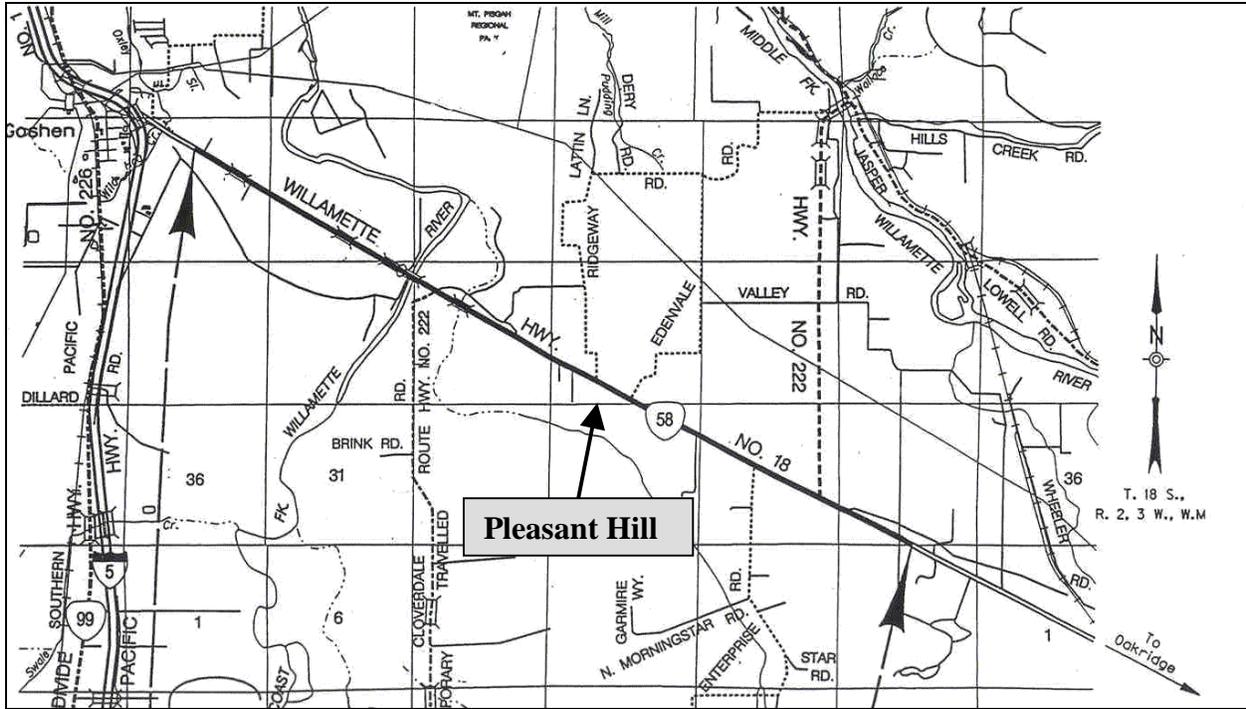


Figure 3.7: Project Location of Goshen - Pleasant Lane Section.

The Goshen - Pleasant Lane Section project spanned two construction seasons. The contract was awarded on February 10, 1999 and work began in April 1999. Construction was substantially complete by November 2000. In addition to reconstructing and widening the existing highway, the scope of work included adding concrete curb and gutter, and concrete driveways in the business area of Pleasant Hill. Figures 3.8 and 3.9 show some of the businesses in Pleasant Hill located on the north side of OR Route 58 prior to construction.

During construction, blue tubular markers and blue signs were used to designate the accesses to businesses. Originally, when the contract was let for the Goshen - Pleasant Lane Section project, no devices were planned for use on this project. However, as a result of the scope changes made on the Sweet Home project, a decision was made to incorporate the use of blue tubular markers and business access signs into this project. The requirements for using blue tubular markers and business access signs were inserted into the basic contract as added work under a negotiated price agreement.

The blue tubular markers and business access signs would be used at the accesses affected by construction; they would be configured in the scheme shown in Figure 3.2.



Figure 3.8: Businesses in Pleasant Hill Adjacent to OR Route 58 Prior to Construction



Figure 3.9: Businesses in Pleasant Hill Adjacent to OR Route 58 Prior to Construction

As noted earlier in Section 1.3, the research effort included recording baseline and “during construction” traffic counts at each business site, and conducting business and motorist surveys. In the next two chapters, the data collection activities in Sweet Home and Pleasant Hill are described in greater detail.

4.0 SWEET HOME DATA COLLECTION

4.1 TRAFFIC COUNTS

In Sweet Home, traffic count data was collected using standard single road tube sensor TT-4 counters. Each count was taken for a 7-day period.

As mentioned in Section 3.2.1, over 90 businesses border the highway within the project limits. About 60% of those businesses were in the downtown core area, where motorists typically accessed the businesses using a connecting side street to reach shared parking areas behind the business. Additionally, most of the on-street parallel-parking spaces were removed by the project in order to improve traffic flow. Because of the limited number of individual access drives in the downtown core, few counts were taken in this section of Sweet Home.

Seven-day traffic counts were recorded at 20 business sites prior to construction. Some of the sites were shared driveways for more than one business. Several constraints affected the number of counts that could be taken. One constraint was the number of counters available from ODOT's Region 2 Traffic Section. Because of ongoing traffic counting commitments, only a limited number of counters could be used on this project. Secondly, during the same timeframe that counts were being taken in Sweet Home, counts were also being recorded in Pleasant Hill. Additionally, problems occurred with road tubes being severed or disconnected from the counter. Most sites had at least two driveways (some had as many as five); each driveway required a separate road tube and counter. If a road tube was damaged during the week, the entire week's count at the business site was invalidated. This occurred on about 10% of the counts.

Of the 20 business locations that were counted prior to construction, ten were counted again when construction started. Only half of the original sites had work affecting their driveway or requiring traffic control near their driveways. The site locations where both "before" and "during" counts were made are listed in Table 4.1. To maintain the confidentiality of each business, the sites are described using a broad categorization.

Table 4.1: Classification of Businesses with Traffic Counts in Sweet Home

<i>Type of Business</i>	<i># Counted</i>
Mixed Use Retail	2
Retail - Gas/Grocery	1
Retail – Gas	1
Fast Food Restaurant	2
Retail – Specialty	1
Retail – Grocery	2
Restaurant	1

After construction began, Temporary Business Access signs were placed at driveways when there were construction activities in the vicinity of the business site. Typically, these activities involved sidewalk and driveway construction which blocked a travel lane. The Temporary Business Access signs were mounted on two types of sign supports, either an A-frame (Type II) barricade (Figure 4.1) or a tripod support (Figure 4.2). Signs were placed to be visible to oncoming traffic that could turn right from the adjacent travel lane. In most cases, only one sign was used per access, either because: (a) a raised median prevented entry from the opposite travel lane; (b) there were space constraints; or (c) the sign could not be placed to be easily seen by traffic in the opposite travel lanes.



Figure 4.1: Business Access Sign Mounted on Type II (A-Frame) Barricade



Figure 4.2: Business Access Sign Mounted on Tripod

Traffic counting began on May 11, 1999 prior to construction. Each site was counted at least one time. Additional baseline counts were taken at businesses depending on the availability of counters and the construction schedule. The last counts were completed on September 16, 1999 when construction was substantially complete. Temporary Business Access signs were present for all “during construction” counts. Most of the business sites were counted only one time during construction, as typically, the work affecting the business access (sidewalk and driveway construction) was completed within a one- to two-week timeframe. Also, as discussed earlier, there were several instances when counter tubes were damaged, thus negating a week-long count for a business site. The average week-long counts for the ten sites that were counted both before and during construction are summarized in Table 4.2.

Table 4.2: Summary of Average Week-long Traffic Counts for Businesses in Sweet Home

Business Category	Average When There was No Construction Activity Present	Number of Weeks Counted	Average During Construction With Signs in Place	Number of Weeks Counted	Difference in Average Counts	% Difference in Average Counts
Mixed Use Retail (a)	12,098	4	11,636	1	-462	-3.8
Retail – Grocery (a)	6,120	3	5,183	1	-937	-15.3
Retail - Gas/Grocery	4,398	3	5,294	4	896	20.4
Retail – Grocery (b)	3,338	1	2,906	1	-432	-12.9
Mixed Use Retail (b)	3,075	3	3,134	1	59	1.9
Retail – Gas	1,088	2	1,486	2	398	36.6
Fast Food Restaurant (a)	972	2	924	1	-48	-4.9
Fast Food Restaurant (b)	939	1	339	1	-600	-63.9
Retail – Specialty	610	1	248	2	-362	-59.3
Restaurant	162	1	263	2	101	62.4
Total	32,800		31,413		-1,387	-4.2

At six business sites, average traffic counts decreased during construction. The greatest percentage drops were experienced by a fast food restaurant (63.9%) and a specialty retail store (59.3%). Alternatively, a restaurant (62.4%) and a retail-gas outlet (36.6%) saw the greatest gains in traffic. Overall, there was a 4.2% decrease in numbers of vehicles accessing the ten businesses during construction. Based on the limited traffic counts, it is difficult to draw conclusions about whether certain types of business activity are more susceptible to changes because of construction.

Traffic was also impacted by summer recreational travel. U.S. Route 20 through Sweet Home is a major travel corridor that typically sees seasonal changes in traffic. An indicator of the seasonal volumes along the corridor is provided by ODOT’s Automated Traffic Recorder (ATR) sites near Sweet Home. Figure 4.3 provides the average daily traffic (ADT) data for 1999 recorded at an ATR site located near Waterloo, approximately 13 km northwest of Sweet Home on U.S. Route 20, and at an ATR site close to Upper Soda on U.S. Route 20, about 39 km east of Sweet Home.

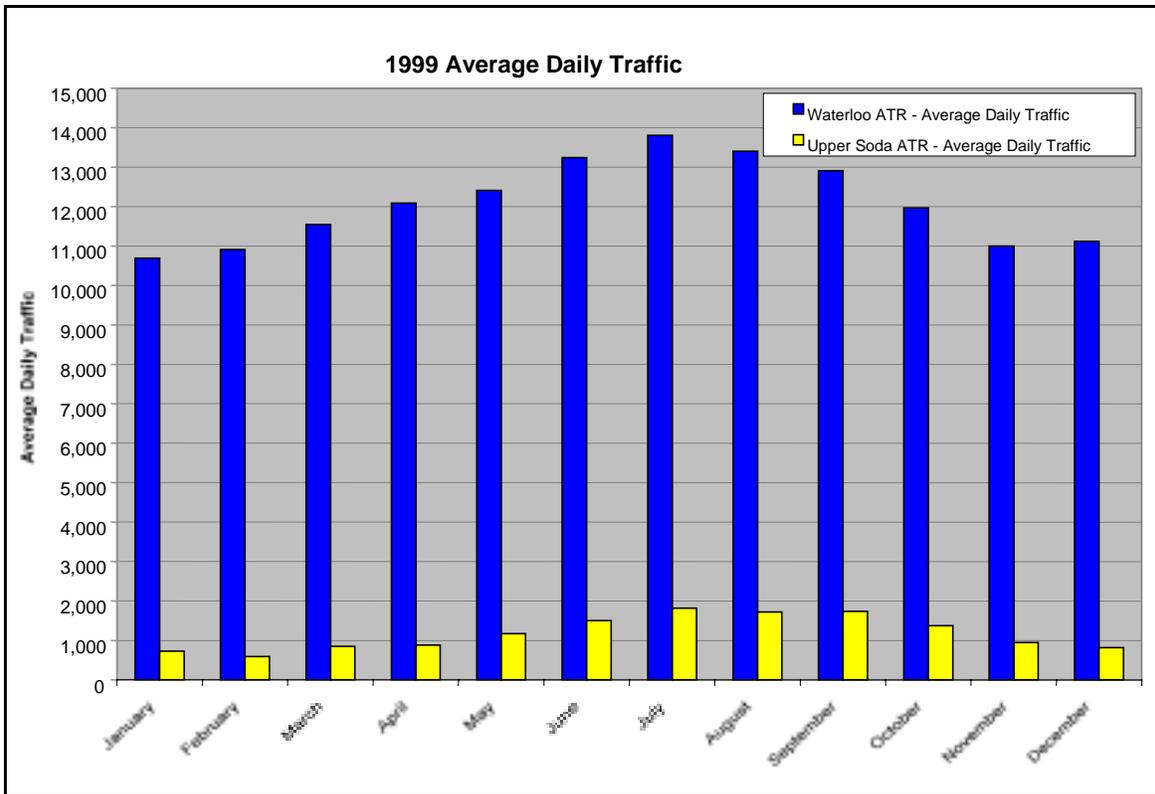


Figure 4.3: 1999 Average Daily Traffic for Waterloo and Upper Soda ATR sites.

The highest ADTs recorded at both sites occur in July and August. The baseline traffic counts for most business locations were taken in May and June, prior to the heaviest seasonal traffic. For the four sites that experienced increases in traffic during construction, those increases could be attributed to seasonal increases in traffic. Alternatively, seasonal variability could have also affected the six business sites that showed decreases in traffic during construction. It can be theorized that those decreases would have been even greater if there were no seasonal influx of traffic through Sweet Home in July and August.

4.2 SURVEY OF MOTORISTS AND BUSINESSES IN SWEET HOME

Telephone surveys were conducted by the University of Oregon’s Survey Research Laboratory in mid-October, 1999 to determine the impact of the highway construction on access to businesses and to judge the effectiveness of the Temporary Business Access signs. Key findings from the business and motorist survey results are presented in the next two sections of this report.

The complete business and motorist questionnaires are found in Appendices A and B. The complete results for both surveys including frequency distribution tables and verbatim narrative responses to open ended questions are available from ODOT’s Research Group.

4.2.1 Business Survey

The business survey included 28 respondents out of a total of 41 businesses that were contacted. The respondent was either the manager or owner of the business. Some of the businesses contacted would not participate; for others, the manager or owner was not available, even after repeated attempts. Three businesses could not be reached because of incorrect phone numbers.

Figure 4.4 shows the answers to the question about the difficulty in locating the business entrance due to construction. The distribution of responses was evenly split, with half of the responders feeling their customers had a difficult time locating the entrance to their business. As Figure 4.5 shows, 16 of 28 respondents (57%) felt they lost business because of reduced access. Yet, when asked if ODOT could have done more to provide better access, 15 of 24 (62%) said no (Figure 4.6).

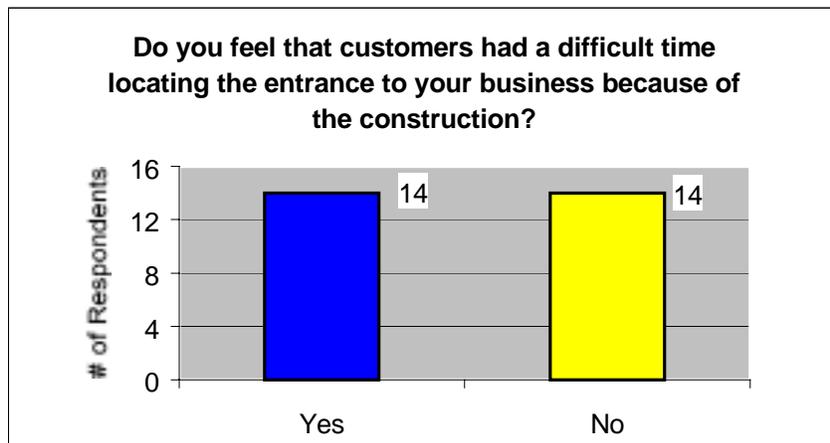


Figure 4.4: Distribution of Answers to “Difficulty Locating the Business Entrance” Question



Figure 4.5: Responses to Question About Customer Impact with Reduced Access

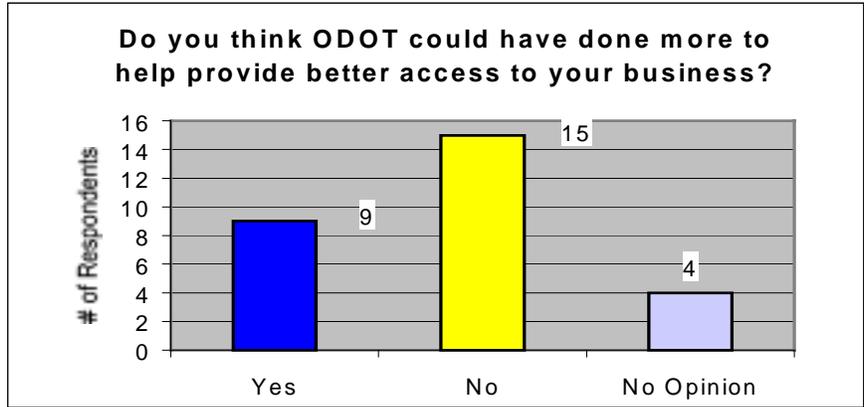


Figure 4.6: Responses from Businesses about ODOT Doing More to Provide Better Access

Fourteen of 26 respondents (54%) had Temporary Business Access signs placed in front of their driveways during construction (Figure 4.7). As seen in Figure 4.8, 12 of the 14 businesses (86%) indicated the signs helped customers locate their driveways.

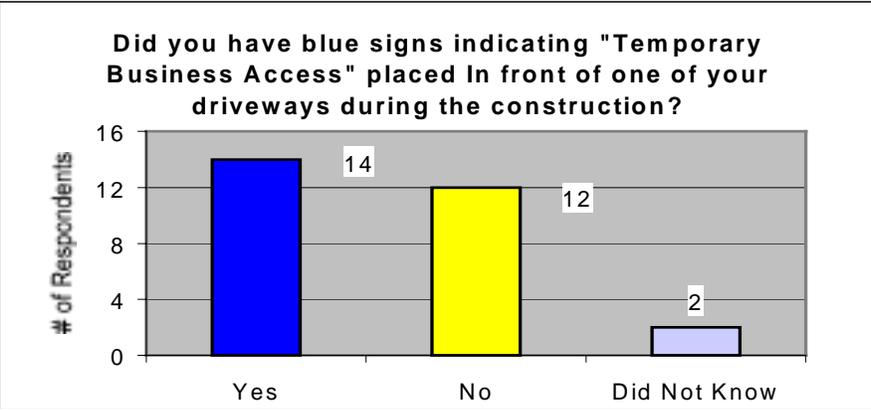


Figure 4.7: Number of Responding Businesses with Temporary Business Access Signs



Figure 4.8: Responses to "Did the Business Access Signs Help Customers " Question

Businesses were also asked two open-ended questions. First, they were asked how they were impacted by construction. Most of the 28 businesses that answered this question said they lost at least some business; several said they were severely impacted. Eight however, reported only minimal or no adverse impact.

The second open-ended question was asked of those who answered yes to “Do you think ODOT could have done more to help provide better access to businesses?” (see Figure 4.6). The follow-on question was “What could ODOT have done to help provide better access to your business?” Two of the nine who answered this question commented directly about the signs; both felt the signs should be larger to be more visible to the motorist.

In general comments made at the end of the survey, one of the businesses indicated the signs were placed inconsistently. The respondent noted that on some days there were several signs at the driveways, while on other days during construction there were none. Two other businesses remarked that the signs were placed at their driveways only after they requested them.

4.2.2 Motorist Survey

The motorist survey reached 371 respondents; most lived in Sweet Home. Additionally, they all had driven through the highway construction area at least once during the project duration.

4.2.2.1 Frequency Distributions

Figure 4.9 provides a distribution of the number of trips taken through the construction area. Twelve people surveyed could not provide an answer to how many trips they made through the construction site, thus, the distribution total is 359. Over half of those traveling through the Sweet Home project site had driven through the construction area more than 50 times.

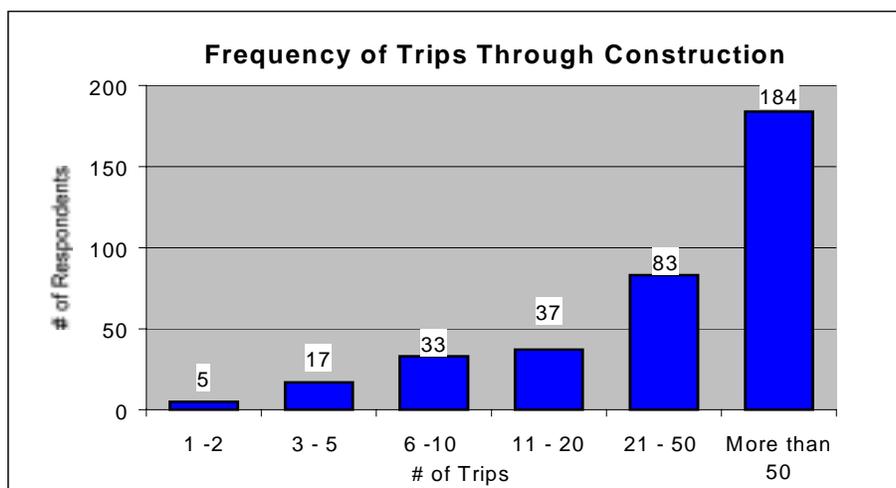


Figure 4.9: Frequency Distribution of Number of Trips Through Construction Area

Figure 4.10 shows that 59% (219) of those surveyed said they experienced difficulty getting into and out of the businesses.

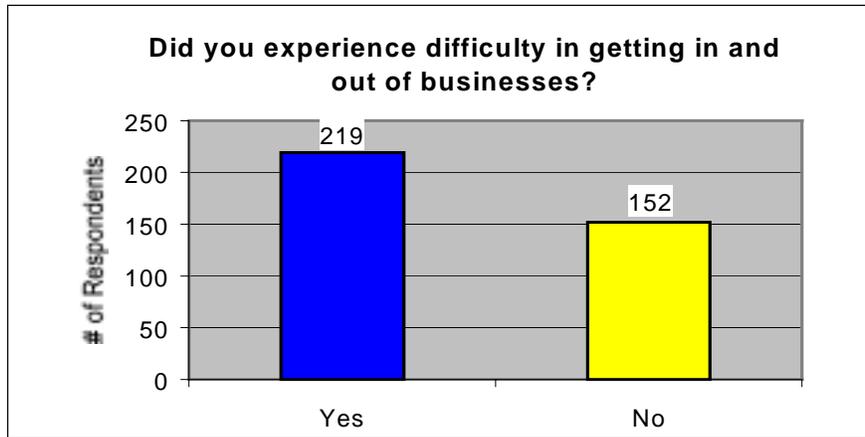


Figure 4.10: Responses to Difficulty Getting in and Out of Businesses

Figure 4.11 shows that a substantial majority of people (80%) noticed the Temporary Business Access signs used during construction. Additionally, of the 292 people who noticed the signs, 242 (83%) indicated the signs helped them locate the business access (Figure 4.12).

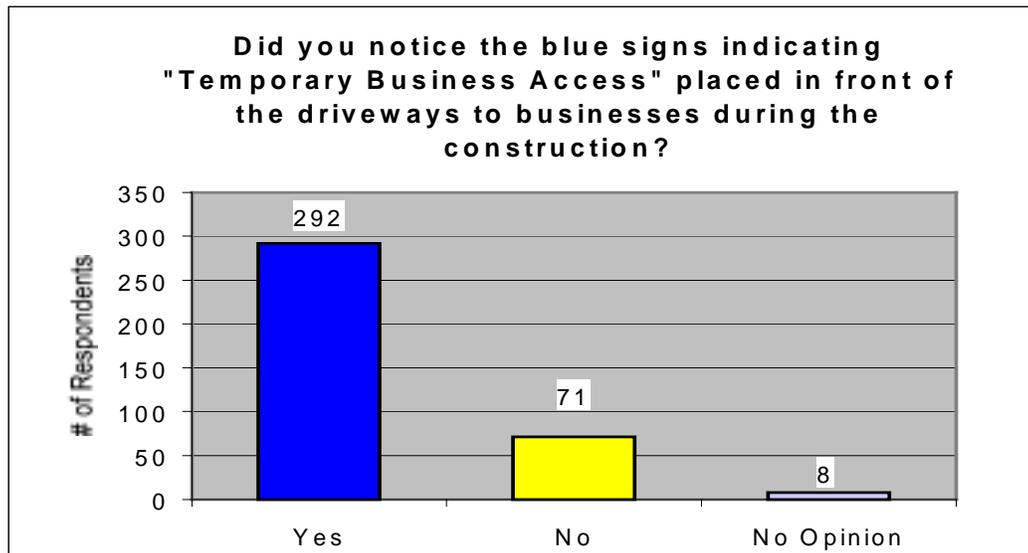


Figure 4.11: Responses About Noticing the Blue “Temporary Business Access” Signs

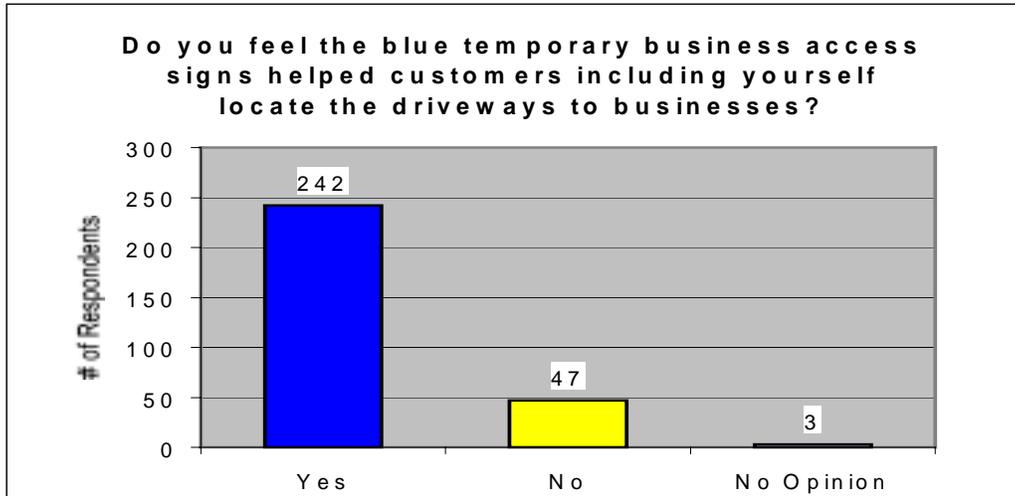


Figure 4.12: Responses on Whether the Business Access Signs Helped Customers

Figure 4.13 shows that over 57% (213) of people surveyed believed that ODOT could not do any more to help businesses in Sweet Home during construction. It can be inferred from the response to this question that most people in Sweet Home believed ODOT did as much as possible to mitigate the impact experienced by businesses.

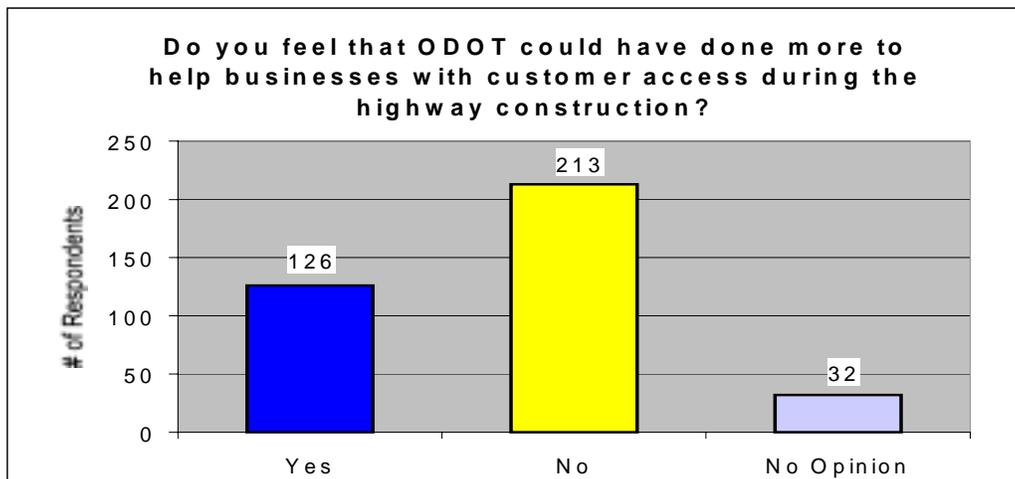


Figure 4.13: Responses from Residents About ODOT Doing More to Provide Better Access

4.2.2.2 Cross Tabulations

In addition to the responses reported above, several tables of cross tabulations were developed using the motorist survey data. Cross-tabulation tables are two-variable frequency distribution tables that present the results of two questions simultaneously in order to determine if any relationships exist between the two sets of answers.

A cross-tabulation table was created to analyze the distribution of responses to the question about noticing the blue business access signs by the frequency of trips made through the construction work areas. Table 4.3 presents the results, which indicate that as the number of trips increase, greater percentages of drivers notice the signs. For example, 88% of the respondents who made more than 50 trips through the project area noticed the signs, whereas only 65% who traveled 3-5 times noticed them.

Table 4.3: Cross Tabulation of Responses to “Did You Notice Signs?” by Frequency of Trips

Number of Times Traveled in Project Area	Did You Notice the Blue "Business Access" Signs?		
	Yes	No	Grand Total
1-2	2 (40%)	3 (60%)	5 (100%)
3-5	11 (65%)	6 (35%)	17 (100%)
6-10	22 (73%)	8 (27%)	30 (100%)
11-20	21 (57%)	16 (43%)	37 (100%)
21-50	68 (83%)	14 (17%)	82 (100%)
More than 50	158 (88%)	22 (12%)	180 (100%)
Grand Total	282	69	351

Another cross tabulation table looked at the distribution of responses to the question about whether the blue business access signs helped, compared to the frequency of trips made through the project area. Table 4.4 shows the results of this cross tabulation. The results show that a similar proportion of respondents (81 to 87%) for each trip frequency (except for the 1-2 times frequency) believed the signs helped customers locate the business access.

Table 4.4: Cross Tabulation of Responses to “Did the Signs Help?” by Frequency of Trips

Number Of Times Traveled In Project Area	Do You Feel the Blue Temporary Business Access Signs Helped Customers Including Yourself Locate the Driveways to Businesses?		
	Yes	No	Grand Total
1-2	1 (50%)	1 (50%)	2 (100%)
3-5	9 (82%)	2 (18%)	11 (100%)
6-10	17 (81%)	4 (19%)	21 (100%)
11-20	18 (86%)	3 (14%)	21 (100%)
21-50	59 (87%)	9 (13%)	68 (100%)
More than 50	129 (82%)	28 (18%)	157 (100%)
Grand Total	233	47	280

In a third cross tabulation, the answers to the following questions are shown in Table 4.5: (a) Do you feel the blue Temporary Business Access signs helped customers including yourself locate the driveways to businesses? and (b) Have you had difficulty getting into or out of any business in Sweet Home?

Table 4.5: Cross Tabulation of “Did the Signs Help?” and Difficulty Accessing Businesses

	Do You Feel the Blue Temporary Business Access Signs Helped Customers Including Yourself Locate the Driveways to Businesses?		
	Yes	No	Grand Total
Have You Had Difficulty Getting Into or Out of Any Business in Sweet Home?			
Yes	137 (57%)	39 (83%)	176 (61%)
No	105 (43%)	8 (17%)	113 (39%)
Grand Total	242 (100%)	47 (100%)	289 (100%)

The cross tabulation was done to determine if a relationship existed between the blue signs helping and the difficulty experienced by people trying to access businesses. As shown in Table 4.5, a total of 242 people answered “yes” to the question about business access signs helping them locate the driveways to businesses. Of those 242, 57% indicated they also experienced difficulty getting in and out of businesses. In contrast, there were 47 respondents who answered “no” to the question about the business access signs helping them. Of the 47 who did not find the signs helpful, 83% said they had difficulty accessing businesses. Comparing these results suggests that the Temporary Business Access signs were helpful in reducing the difficulty in accessing businesses.

To determine if there was any statistical correlation between the answers, a chi square test for independence was run. A chi-square test is used to measure the relationship between qualitative variables obtained from survey results. In this case, the variables were the answers to questions of the business access signs helping and the difficulty getting into and out of businesses. The results are presented in Table 4.6, and are explained below.

Table 4.6: Results of Chi-Square Test for Independence

Theoretical Chi-square	3.84
Degrees of freedom	1
Significance Level	0.05
Observed Chi-square	11.49

The theoretical value of chi-square was 3.84. The theoretical value for chi-square is determined from statistical tables, using the degrees of freedom associated with a cross tabulation table and the assumed significance level. Degrees of freedom are calculated by multiplying: (a) one less than the number of rows in the table, by (b) one less than the

number of columns in the table. The assumed significance level is 0.05, which represents the probability of error that is acceptable when making an inference that a relationship exists between the answers in a cross tabulation. This means there is a 5% probability that, in the long run, an incorrect conclusion will be made that a relationship exists. The “observed” chi-square statistic, calculated for the cross-tabulated questions, is 11.49. Since the observed chi-square (11.49) is greater than the theoretical value (3.84), it could be inferred that a statistically significant relationship exists.

Although there is a statistically significant relationship between the business access signs and reduced difficulty locating and accessing business driveways, the signs have not solved the problem. As previously noted, the signs were noticed by 80% of survey respondents, of which 83% said they helped. However, even with the signs in place, a majority of the people surveyed (59%) still experienced difficulty getting in and out of businesses.

When asked about their difficulty, many of the specific problems addressed by the respondents related to the following issues:

- Lane closures;
- Temporary detours;
- Blocking of cross streets;
- Closure of a business access for driveway and sidewalk construction;
- Difficulty finding parking;
- Problems accessing a business during the paving phase;
- Day to day changes in lane and business access closures;
- Elevation differences between the pavement surface and driveway after the existing pavement wearing course was removed and prior to new pavement being placed; and
- Turning movements from a travel lane into the business.

Observations about the Temporary Business Access signs were given in answers to another open-ended question. Those who said yes to the question “Do you feel ODOT could have done more to help businesses with customer access during the highway construction?” were asked “What do you think ODOT could have done to help customer access to businesses during construction?” Several people commented on the size and position of the signs. For example, one respondent noted, “... the signs are kind of hard to see and at waist level so they need to be bigger and maybe fluorescent.” Another advocated, “...more noticeable signs, and at night....we had no idea where to go.”

Additionally, the wording on the sign, “Temporary Business Access,” may have caused some confusion. During most of the construction, the signs were used to delineate an alternate driveway to a business site while another driveway was being reconstructed. Some people commented about the sign’s placement. For example, one remarked, “They put the blue signs in the normal entrances, so it was kind of funny that they were the same entrances as always but labeled differently.”

5.0 DATA COLLECTION IN PLEASANT HILL

5.1 TRAFFIC COUNTS

Traffic counting at Pleasant Hill businesses started in April 1999 prior to the start of construction work in the business area of the Goshen-Pheasant Lane Section project. Single road tube sensor TT-4 counters were used, and all counts were taken for a 7-day period. There are 22 businesses in Pleasant Hill that are located either adjacent to the highway or on a connecting side street. Of those 22 businesses, only four businesses have individual unshared access drives. The others share access drives directly off of OR Route 58 or their driveways are located on an adjacent side street.

Counts were taken at 17 separate access drives throughout the construction period. These 17 driveways were located at seven different business sites. Two of the sites included a number of different businesses, where the other five sites served only one business. The seven business sites which were counted are listed in Table 5.1. To maintain the confidentiality of each business, the sites are described using a broad classification.

Table 5.1: Classification of Business Sites that were Counted in Pleasant Hill

Type of Business	Number Counted
Mixed Use Retail	1
Retail – Gas/Grocery	1
Retail – Grocery	1
Restaurant	2
Mixed Use Service	1
Single Use Service	1

Construction began in the Spring of 1999 and continued until November 2000. Blue tubular markers and signs were placed at the business access when there was construction activity in the vicinity of the business site. Typically, this work involved sidewalk and driveway construction, shoulder and road construction, paving, and drainage pipe installation. The signs were mounted on a Type II (A-frame) barricade which was placed in front of a taper of blue tubular markers at the business access (Figure 5.1). Since the geometry of the accesses was not the same for each access, the tubular marker spacing varied at different locations, ranging from one to three meters. Figure 5.2 and Figure 5.3 show two more examples of sign and cone placement.



Figure 5.1: Business Access Sign and Blue Tubular Markers



Figure 5.2: 3 m Spacing of Blue Tubular Markers at two Accesses



Figure 5.3: 1 m Spacing of Blue Tubular Markers at Business Access

Additionally, two informational signs, one at each end of the project limits, were placed to alert motorists as they entered the construction work zone about the meaning of blue tubular markers. The signs (1219 mm x 914 mm), as seen in Figure 5.4, displayed a blue tubular marker and text (“Indicates Business Access”) on a white background.



Figure 5.4: Informational Sign Alerting Motorists to Blue Tubular Markers

The sign in Figure 5.4 shows a blue tubular marker with two bands of white reflective sheeting. The blue tubular markers actually used on this project were delineated with blue reflective sheeting as seen in Figures 5.1-5.3. Blue reflective sheeting was used to further distinguish the blue tubular markers from the orange ones, especially at night, since white sheeting is used on the orange markers.

The first series of traffic counts for businesses began on April 15, 1999. The last count was completed November 1, 2000, when the construction was substantially complete.

Of the seven different business sites where initial counts were made, three were accessed directly from OR Route 58. The other four were reached by traveling a short distance on an intersecting side street. At the start of the construction period, there was some uncertainty as to whether the sites not directly accessed from OR Route 58 would be affected by the construction. Due to the uncertainty, baseline counts were made at all seven sites. In the course of construction, it became apparent that three of the sites would not be affected by construction activity; thus, only four sites in Pleasant Hill required signs and blue markers at their drives during the construction period. The results of traffic counts at these four sites are presented in this report. The traffic count data collected for the other three sites is not presented, but is available from ODOT’s Research Group.

Table 5.2 provides a summary of the average counts for the four business sites that were counted throughout the construction period. The data contained in the column headed “Average When There was No Construction Activity” is based on traffic counts taken when there was no construction occurring that affected customer accessibility to the business. Throughout the entire

period from April 1999 to October 2000, there was usually construction taking place within the 9.8 km project length. However, unless the work directly impacted accessibility, the counts were categorized as “No Construction Activity Present.” As a further check to ensure the counts were properly categorized, the ODOT Project Inspector’s Daily Reports were reviewed for the 18-month construction period to verify the location of construction activity and to cross-reference this information with the traffic count data categories.

Table 5.2: Summary of Average Week-long Traffic Counts for Business Sites in Pleasant Hill

Business Category	Average When There was No Construction Activity Present	Number of Weeks Counted	Average During Construction Using Signs and Tubular Marker	Number of Weeks Counted
Mixed Use Retail	10,527	24	10,545	11
Retail – Gas/Grocery	3,290	23	3,742	7
Restaurant (a)	2,851	28	2,434	7
Retail – Grocery	908	15	1,261	3

Analysis for Pleasant Hill differed from the comparisons done for Sweet Home. Section 4.1 described how the Sweet Home traffic counts at business accesses were compared for (a) the averages at each site when there was no construction activity present; and (b) the averages during construction with traffic control devices in place. The Sweet Home data was collected over a short timeframe, with a limited number of counts made for each business. So for this data set, comparing averages was a reasonable method to help understand the effect of employing signs at business accesses.

In Pleasant Hill, the number of counts was much higher, and the data was obtained over an 18-20 month period of time. A more suitable method of analysis was needed. In sections 5.11 through 5.15, the data analysis methods are described, and the results of the Pleasant Hill traffic counts are presented for each of the four business sites.

5.1.1 Mixed Use Retail

At this site, five access drives were counted initially. To improve traffic flow and enhance safety, one of the accesses was eliminated by the construction when sidewalks, curbs and gutters were constructed in May 2000. Week-long traffic counts were conducted at this site 34 times during the construction period. Eleven of the counts were taken when construction activity was in the vicinity of the business accesses and blue tubular markers and signs were used. Figure 5.5 shows a plotted history of the week-long counts from April 1999 to September 2000. Each data point corresponds to a one-week count. Two sets of data points are plotted on the graph, which represent: (a) no construction was present in the vicinity of businesses accesses; and (b) construction was present and blue tubular markers and signs were used to mark the accesses.

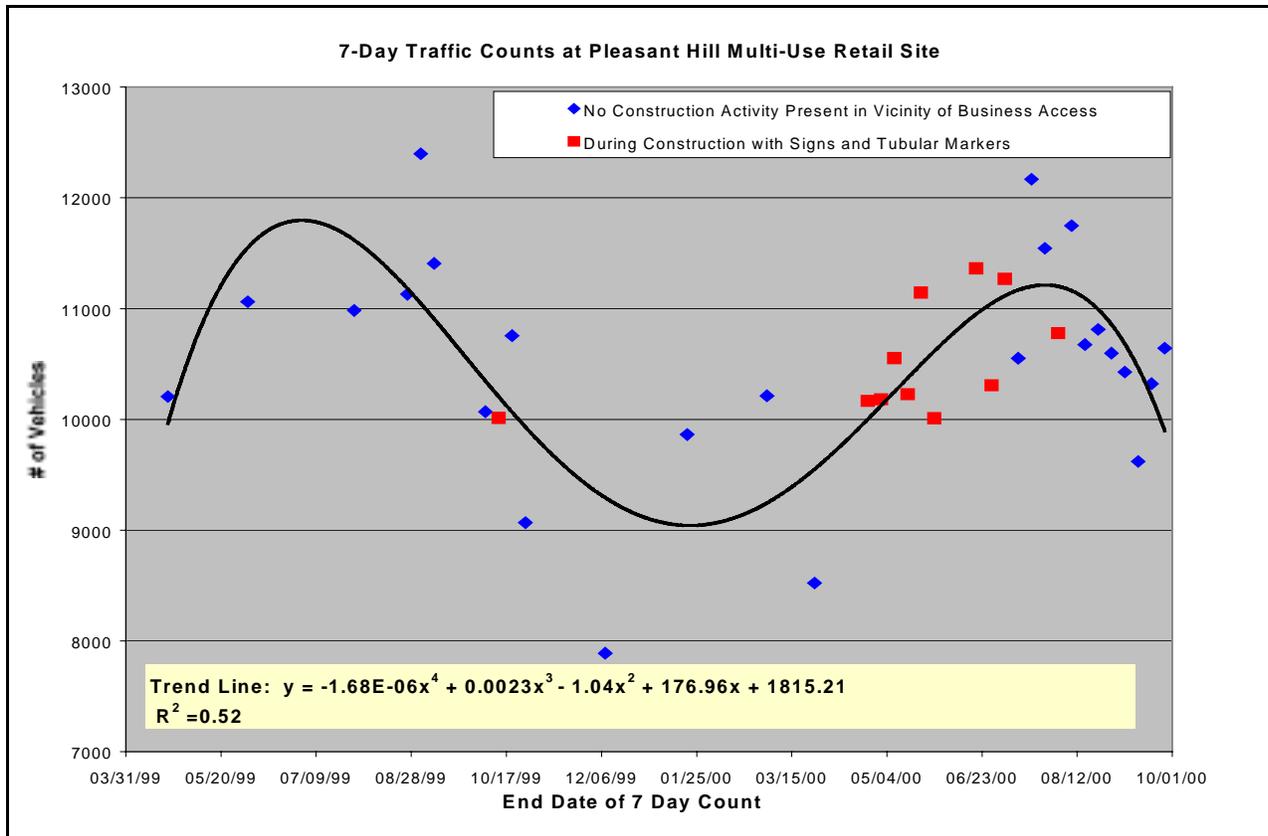


Figure 5.5: Plot of Traffic Counts Recorded at Multi-Use Retail Site in Pleasant Hill

The plot makes it apparent that the pattern is seasonal, with the highest traffic counts occurring in the summer. A trend-line based on a polynomial regression of the “no construction present” data is also plotted. The coefficient of determination (R^2) for the trend line is 0.52, which is a measure of the “goodness of fit” of the regression line to the data points. In other words, the time of the year when a count was taken explains 52% of the variation in traffic counts at this particular business site. (If the trend line fit exactly through each of the data points, the R^2 value would be 1.0, meaning that 100% of the variance in traffic counts could be explained because of seasonal patterns.)

The “no construction” trend line was used to evaluate the effectiveness of the signs and blue tubular makers by comparing it to the counts made during construction when these devices were used. A residual value was calculated for each data point that represented counts taken when both construction and devices were present (the residual is the vertical distance from the trend line to the data point). The data points of counts taken when signs and tubular markers were used are distributed almost evenly on both sides of the trend line; six are above and five are below. The net residual (sum of residuals) is -386 and the average residual is -35. The average residual is only 0.3% of the total trend line average value (10,527). This very small average residual indicates that when construction was present and the signs and tubular markers were used, there was no significant variation from normally expected travel.

5.1.2 Retail Gas/Grocery

The two accesses at this site were counted 30 times during the construction period. Six of the counts were taken when construction activity was in the vicinity and blue tubular markers and signs were used at each access. Figure 5.6 shows a plotted history of the week-long traffic counts for the “no construction” and “with construction” conditions.

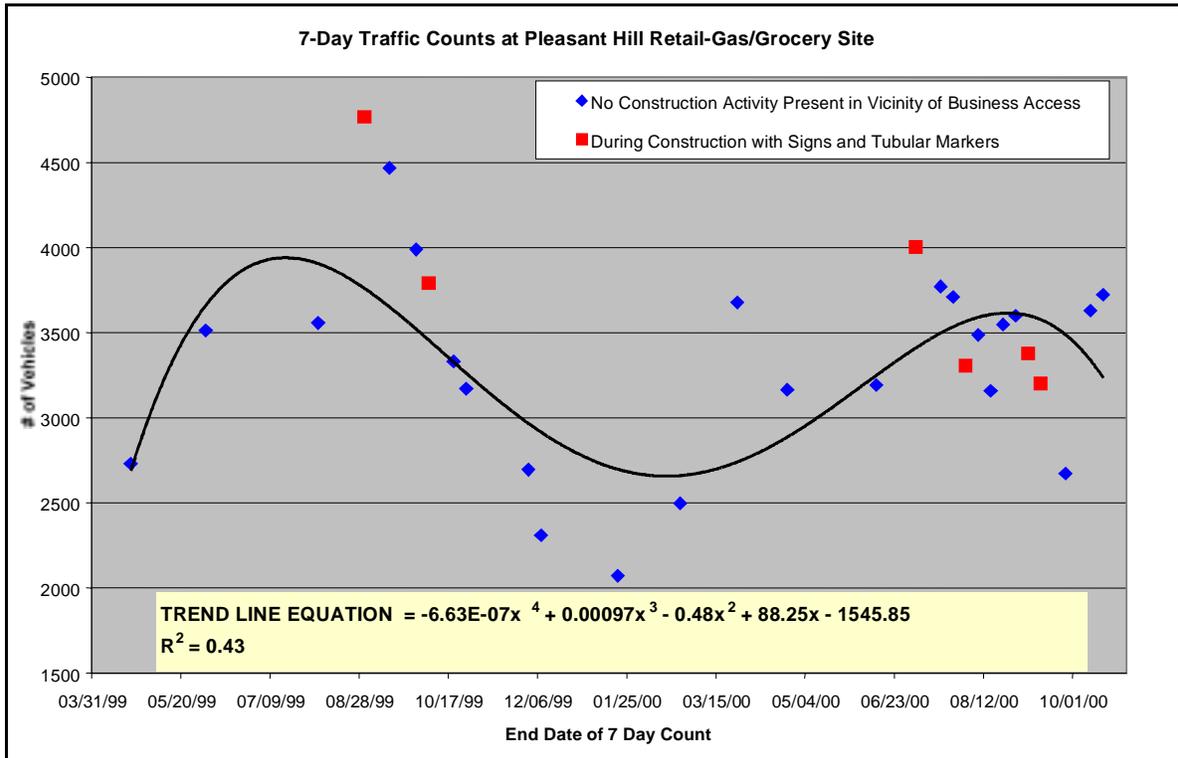


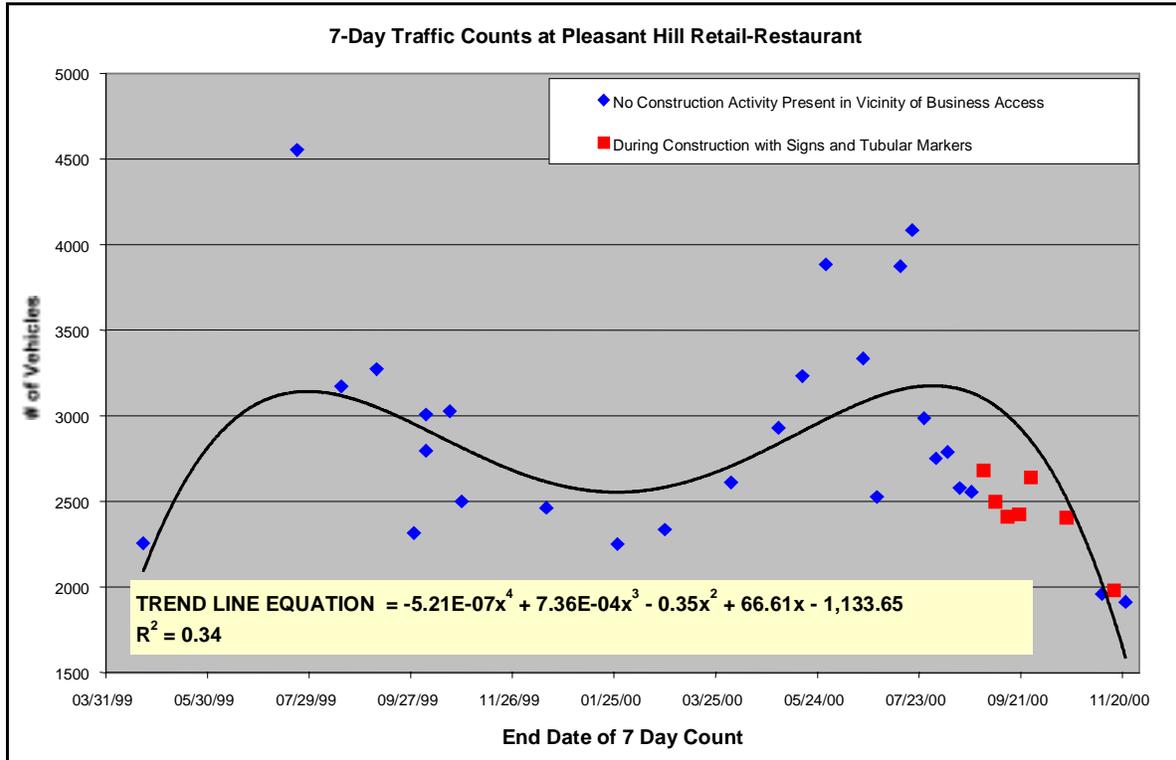
Figure 5.6: Plot of Traffic Counts Recorded at Gas/Grocery Site in Pleasant Hill

The trend line, based on a polynomial regression of the “no construction present” data, also reflects a seasonal pattern with the least traffic occurring in the winter months. The R^2 value for the trend line is 0.43. Three of the six counts taken when signs and markers were used fell above the trend line; one of the three represents the highest count recorded at this site, in the week ending August 31, 1999. The last three counts recorded when the signs and markers were used fell below the trend line. The net residual (sum of residuals) is 1,074 and the average residual is 179. This average residual is 5.4% of the total trend line average value (3,290).

Because the average residual is relatively low and is a positive value, a possible conclusion could be that during construction when signs and tubular markers are used, a slight increase in traffic at the site can be expected. But the net residual value is skewed by the data point for August 31, which had a residual value of 1,008. Discounting this data point yields a net residual closer to zero. Further, because the most recent counts with “construction, markers and signs” were slightly below the trend line, a more reasonable assertion might be that when construction activity was present and blue tubular markers and Temporary Business Access signs were used, the traffic counts remain close to what was normally expected.

5.1.3 Restaurant

The two accesses at this site were counted 35 times during the construction period. Seven of the counts were taken with construction activity in the vicinity and blue markers and signs at each access. Figure 5.7 is the plotted history of the week-long traffic counts for the “no construction” and “with construction” conditions.



5.1.4 Retail-Grocery

Two accesses at this site were counted 18 times during the construction period. The total number of counts was lower for this site because in June 2000, the business owner asked ODOT to stop counting his accesses. Figure 5.8 shows the plotted history of the week-long traffic counts from April 1999 to June 2000.

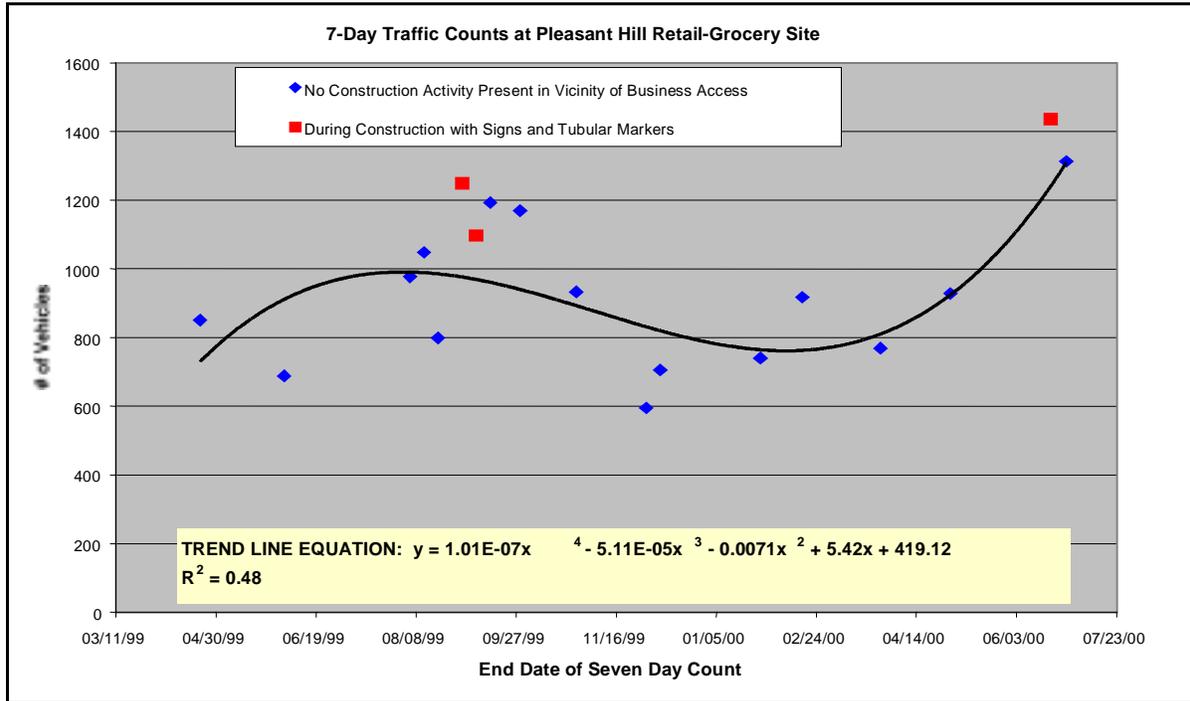


Figure 5.8: Plot of Traffic Counts Recorded at Grocery Site in Pleasant Hill

The plotted trend line of a polynomial regression of the “no construction present” data appears to show a seasonal pattern. However, the extent of the summer peak in 2000 could not be fully developed because of the cessation of traffic counts.

The three data points representing counts taken when signs and tubular markers were used were above the trend line. The average residual is 198, which is 21.8% of the total trend line average value (908). The data seems to support the notion that when construction activity is present, and blue tubular markers and signs are employed, the traffic counts will be higher than what is normally expected.

5.1.5 Discussion of the Traffic Count Data Results

The analysis of the time series data and trend line data show that two of the 4 business sites (retail-gas/grocery and retail-grocery) experienced higher traffic counts during construction when the signs and blue tubular markers were in place. At the mixed-use retail site, the average residual (-35) was only slightly negative, indicating that traffic counts during construction closely mirror the trend line average. The traffic count data at restaurant site was too widely dispersed to

judge the effects of the use of markers and signs, but the other locations indicate that the signs and tubular markers had a positive effect on accessibility to the business site.

However, the reader should view these findings with a degree of caution. There are limitations in the data. First, to reiterate what was said earlier, there were two conditions when traffic counts were recorded: a) when no construction was present in the vicinity of businesses accesses; and b) when construction was present and blue tubular markers and signs were used to mark the accesses.

As discussed earlier in Section 1.3, the original intent was to obtain traffic counts under three conditions: (a) prior to construction; (b) during construction using standard traffic control devices (orange tubular markers); and (c) during construction using the blue tubular markers and signage to indicate business accesses. Early in the project, researchers decided not to pursue this approach because of the nature of construction activities and the layout of the businesses. Pleasant Hill is a rural community with relatively dispersed business sites. Construction activity might occur for weeks or even months at one site, while work at another site might only last for one or two days, thus hampering comparisons. Further, because the Goshen - Pheasant Lane Section project was an initial field trial of blue tubular markers and signs, more emphasis was placed on highway-user understanding. It could confuse the motorist to see some business accesses marked with orange tubular markers while other business accesses were marked with blue tubular markers and signage. Therefore, in Pleasant Hill the simple approach was taken. When construction was present in the vicinity of the businesses accesses, the blue tubular markers and signage would be used.

Another weakness in the traffic count data is the limited number of business sites monitored. A broader focus would have been desirable, but having a limited number of sites allowed for a greater depth of study. If for instance, there were 20 to 30 business sites to count, the frequency of counts at each site would have been much lower because of the limited number of counters.

Even with limitations, the traffic-count data yields noteworthy results. Another tool to assess the impact to businesses and the effectiveness of blue tubular markers and access signs was a telephone survey of businesses in Pleasant Hill and people living there and along the OR Route 58 corridor. The survey results are presented in the next section.

5.2 SURVEY OF MOTORISTS AND BUSINESSES IN PLEASANT HILL

Two telephone surveys (of businesses and motorists) were conducted by the University of Oregon's Survey Research Laboratory in September 2000. Twenty-two businesses were surveyed, as were motorists living along the OR Route 58 corridor between Goshen and Oakridge.

The principal findings from the business and motorist survey are presented in sections 5.2.1 and 5.2.2 of the report. The complete results for both surveys including frequency distribution tables and verbatim narrative responses to open ended questions are available from ODOT's Research Group. The motorist and business survey questionnaires are found in Appendices C and D.

5.2.1 Business Survey

Figure 5.9 shows the responses of the 22 businesses to a question about whether customers were not stopping at the business because of reduced access. The majority of business owners or managers (68%) said that they believed their customers were not stopping because of reduced access caused by the construction. However, when asked if ODOT could have done more to provide the better access, 12 of 22 (55%) said no (Figure 5.10).



Figure 5.9: Responses to Question About Customers Not Stopping Because of Reduced Access

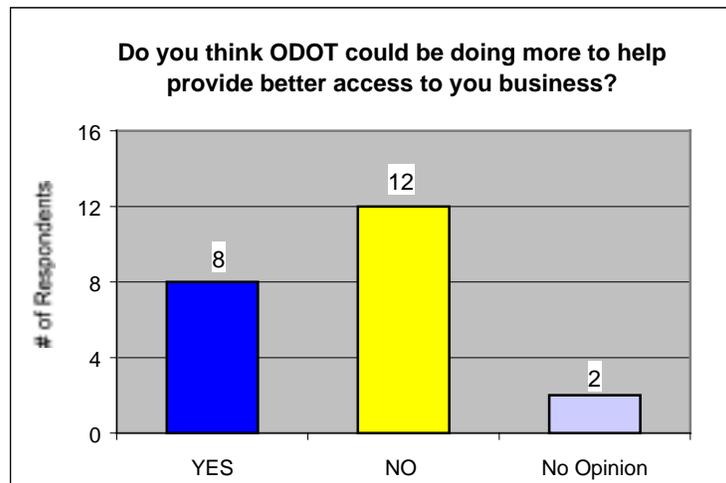


Figure 5.10: Responses from Businesses about ODOT Doing More to Provide Better Access

Twelve of 22 businesses indicated they had blue tubular markers and Temporary Business Access signs placed at their driveways (Figure 5.11). Nine of the 12 businesses were co-located in the multi-use retail site. Figure 5.12 show the results of the answers provided by the 12 businesses when they were asked if the blue tubular markers and Temporary Business Access signs helped customers locate their driveways. Six of 12 said yes and four said no. Two businesses had no opinion.

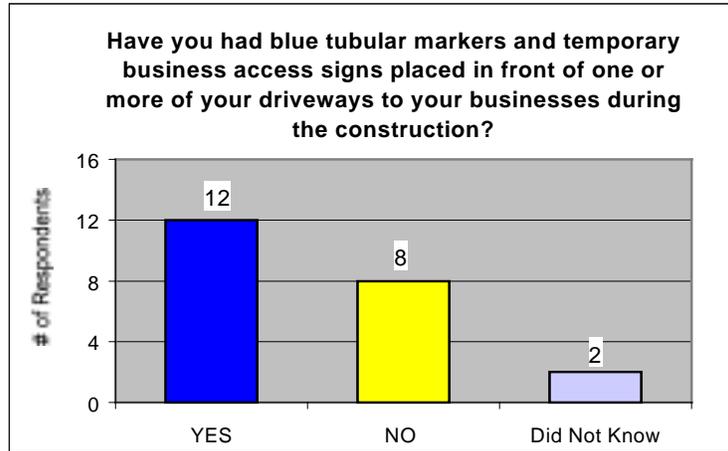


Figure 5.11: Number of Businesses with Blue Tubular Markers and Temporary Business Access Signs

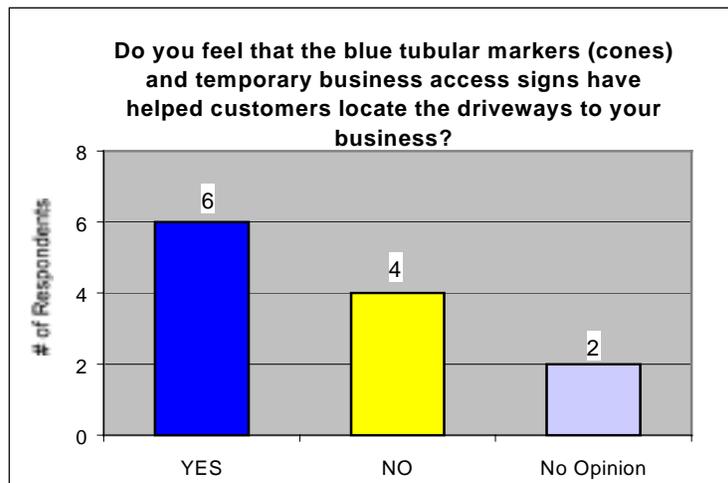


Figure 5.12: Responses to “Do You Feel the Blue Tubular Markers and Signs Helped?” Question

The survey also asked open ended questions. Pleasant Hill businesses were asked about impacts to their company because of construction. Twelve (55%) responded that the construction hurt their business. Some said that because of delays in traffic due to lane closures, people were less apt to stop at a business. One business owner said that motorists were bypassing Pleasant Hill altogether by taking alternate routes. Two others mentioned the impacts caused by the closure of one of their driveways. Yet several businesses indicated the impacts were minimal.

Another open ended question was the follow-on asked to those who answered yes to: “Do you think ODOT could be doing more to provide better access to your business?” (Figure 5.10). They were asked, “What could ODOT have done to improve access?” The answers varied. One talked about the need for better communication between ODOT, the contractor and the businesses. Another expressed frustration with the sequencing of work. A third indicated that their business never got any “blue cones” (tubular markers) to mark their entrance. (In the latter case, the business entrance was from an intersecting side street. The nearest construction was at

the intersection of the side street and OR Route 58. Additionally, the business access was not a clearly marked or paved driveway, but was a wide asphalt apron which would have been difficult to delineate with tubular markers).

5.2.2 Resident Survey

The motorist survey sample size was 381. Each had driven through the highway construction area at least once in the previous two months.

5.2.2.1 Frequency Distributions

Figure 5.13 provides a distribution of the number of trips taken through the construction area by the 381 respondents. Because of the duration of the construction, respondents were asked to estimate their number of trips made in the previous two months. The distribution is fairly dispersed. The most frequently occurring range of trips was 3 to 9, although a sizable number (57) reported they made 80 or more trips through the project area. Since the sample was drawn from people living along the highway corridor from Oakridge to Goshen, many of the frequent travelers could be making work trips.

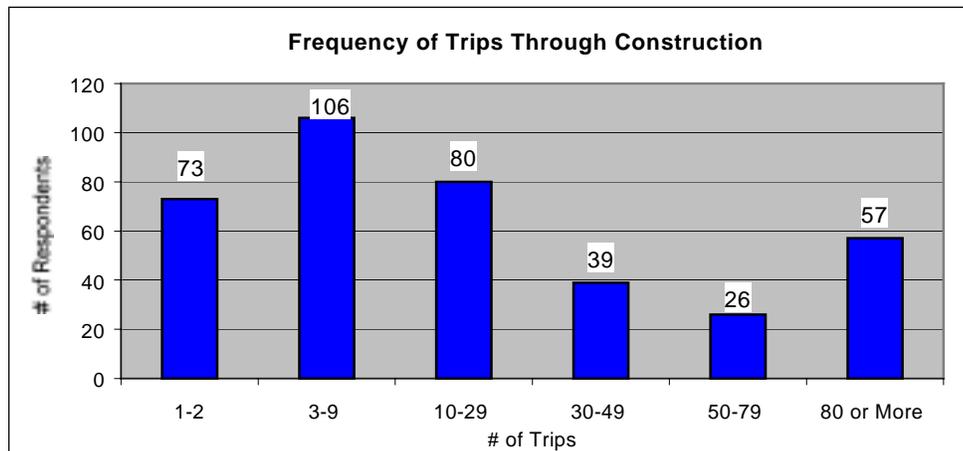


Figure 5.13: Frequency Distribution of Number of Trips Through Construction in Pleasant Hill

Of the people surveyed, most indicated they experienced no difficulty getting into and out of the businesses. Figure 5.14 shows the distribution of responses to the question: “Have you had any difficulty getting into or out of any business in Pleasant Hill?” with 16% (61) of those sampled answering yes.

Those who answered yes to the “difficulty” question were asked an open-ended question about the nature of their problems. Twelve people commented about the long waiting periods in traffic due to a lane closure. There were ten separate comments about blocking of driveways to businesses. Eight people said they had difficulty finding the entrance to a business. Seven others expressed difficulty entering a business because of the elevation difference between highway pavement surface and the driveway after the highway was paved and prior to the driveway being brought up to final grade.



Figure 5.14: Responses to Difficulty Getting Into and Out of Businesses in Pleasant Hill

A substantial majority (315) had no difficulty getting into and out of businesses. Several reasons could be proposed for the high number that did not have difficulty. First, the relatively small numbers of businesses in Pleasant Hill are spread along the length of the project. Secondly, more than half of the respondents had driven through the project area more than ten times in the last two months, and so, were familiar with the site. Third, much of the construction did not directly affect business accesses. However, this is not to imply that construction upstream did not impact a business. For example, some business owners noted that travelers, stuck in long lines of traffic due to a lane closure much further upstream, were less apt to stop at their business even if the accesses were not affected.

A fourth reason could be that the use of markers and signs helped motorists locate business accesses. How effective were they? Figure 5.15 shows that 62% (237) of those surveyed noticed the blue tubular markers and Temporary Business Access signs. The 62% who noticed the markers and signs were asked if the devices helped customers including themselves locate the business accesses. Figure 5.16 shows that 78% (185) responded yes; the markers and signs did help in locating the business accesses.

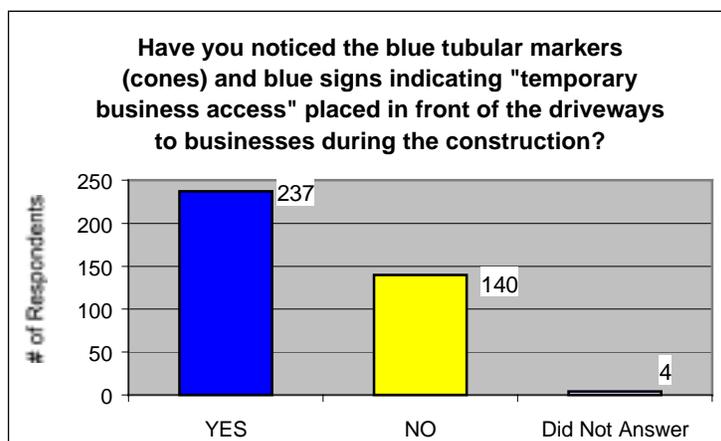


Figure 5.15: Responses about Noticing the Blue Tubular Markers and Signs

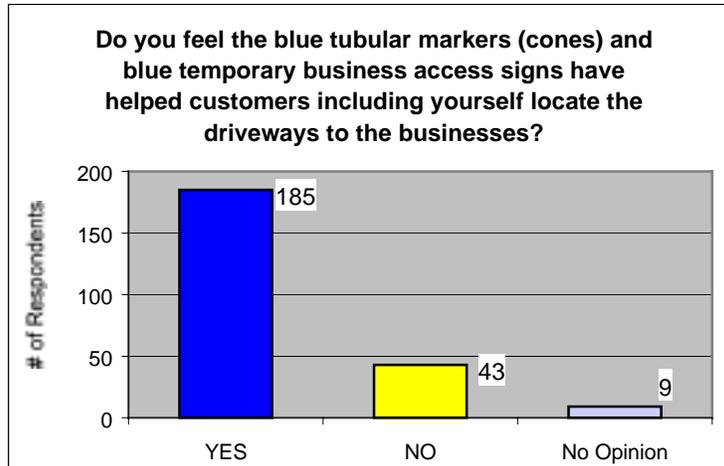


Figure 5.16: Responses on Whether the Blue Tubular Markers and Signs Helped

Figure 5.17 shows that 29% (111) of people surveyed believed that ODOT could do more to help businesses in Pleasant Hill during construction. Slightly over 50% (192) though, felt ODOT could not to anything more to improve customer accesses for business. Almost 21% (78) of those asked had no opinion. The answers show that the majority of people in the Goshen - Oakridge corridor believed ODOT did as much as it could to mitigate the impact experienced by businesses while the highway was reconstructed.

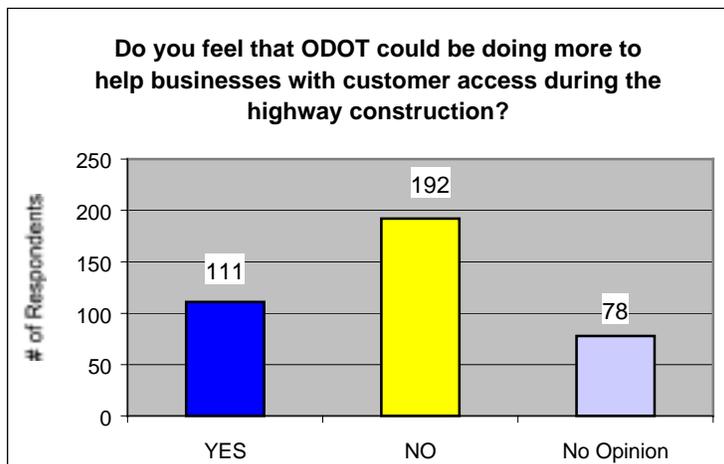


Figure 5.17: Responses on Whether ODOT could be Doing More to Help with Customer Access

Those that answered yes to the question if ODOT could be doing more were asked to elaborate about what ODOT could do to improve access. Thirty people referred to either the Temporary Business Access signs or the blue tubular markers. Some mentioned that the signs need to be large enough to be seen from the highway, so people could recognize them in time to turn safely. Others indicated the signs and markers should be used more consistently. Several people suggested that ODOT do more advertising about the purpose

of the signs and blue tubular markers. There were several comments about improving the visibility of the signs and markers for nighttime conditions.

In addition to addressing the signage and blue tubular markers, people also felt improvements should be made to the following aspects:

- Amount of delay while waiting during a lane closure;
- Traffic control provided by flaggers; and
- Shifting more work to nighttime.

5.2.2.2 Cross Tabulations

A cross tabulation table was created to analyze the distribution of those who answered the question about noticing the blue tubular markers and signs by their frequency of trips through the construction area. Table 5.3 presents the cross tabulation. As the frequency of trips increases, so does the awareness of the blue tubular markers and signs. For instance, of those who traveled in the project area 1-2 times, 37% (26 of 71) noticed the blue tubular markers and signs. At between 3 and 9 trips, the percentage was 53%, and at 80 or more trips, it was 86%.

Table 5.3: Cross Tabulation of “Did You Notice the Markers and Signs?” by Frequency of Trips

	Have you noticed the blue tubular markers(cones) and blue signs indicating "Temporary Business Access" placed in front of the driveways to businesses during the construction?		
Number of Times Traveled in Project Area	Yes	No	Total
1-2	26 (37%)	45 (63%)	71 (100%)
3-9	56 (53%)	49 (47%)	105 (100%)
10-29	57 (72%)	22 (28%)	79 (100%)
30-49	28 (72%)	11 (28%)	39 (100%)
50-79	21 (81%)	5 (19%)	26 (100%)
80 or More	49 (86%)	8 (14%)	57 (100%)
Total	237	140	377

In Table 5.4, another cross tabulation shows the distribution of respondents who indicated the blue tubular markers and signs helped by the frequency of trips made through the project area. The cross tabulation shows the proportion of people saying the markers and signs helped is at about the same (80 to 83%) for each trip frequency category. The only exception is the “50-79” times frequency, which was slightly lower. In this category of trip frequency, 71% indicated they were helped by the blue tubular markers and signs.

Table 5.4: Cross Tabulation of “Did the Markers and Signs Help?” by Frequency of Trips

	Do you feel the blue tubular markers (cones) and blue Temporary Business Access signs have helped customers including yourself locate the driveways to the businesses?		
Number of Times Traveled in Project Area	Yes	No	Total
1-2	18 (82%)	4 (18%)	22 (100%)
3-9	46 (84%)	9 (16%)	55 (100%)
10-29	47 (82%)	10 (18%)	57 (100%)
30-49	22 (81%)	5 (19%)	27 (100%)
50-79	15 (71%)	6 (29%)	21 (100%)
80 or More	37 (80%)	9 (20%)	46 (100%)
Total	185	43	228

Table 5.5 presents a cross tabulation of the respondents’ answers to these two questions:

- 1) Do you feel the blue tubular markers (cones) and blue Temporary Business Access signs have helped customers including yourself locate the driveways to the businesses?, and
- 2) Have you had any difficulty getting into or out of any business in Pleasant Hill?

As in section 4.2.2.2, this cross tabulation was done to analyze the relationship between the presence of the blue tubular markers and signage and the difficulty experienced by people in trying to get into and out of businesses. In Table 5.5, 183 people answered “yes” to the question about blue tubular markers and signage helping them locate the business accesses. Of those 183, 16% said they also experienced difficulty getting into and out of businesses. By contrast, for those who answered “no” to the markers and signs helping them, 29% experienced difficulty accessing the business. The greater percentage of motorists (29% vs. 16%) who had difficulty suggests that a relationship exists between the presence of the devices and the degree of difficulty experienced by the drivers in accessing the business.

Table 5.5: Cross Tabulation of “Did the Devices Help?” and Difficulty Accessing Businesses

	Do you feel the blue tubular markers (cones) and blue Temporary Business Access signs have helped customers including yourself locate the driveways to the businesses?		
Have you had any difficulty getting into or out of any business in Pleasant Hill?	Yes	No	Total
Yes	29 (16%)	12 (29%)	41 (18%)
No	154 (84%)	30 (71%)	184 (82%)
Total	183 (100%)	42 (100%)	225 (100%)

A chi-square test for independence was run to determine if the relationship between the two questions in Table 5.5 was statistically significant. (See page 25 and 26 for more discussion of chi-square analysis.) The results are provided in Table 5.6.

Table 5.6: Results of Chi-Square Test for Independence

Theoretical Chi-square	3.84
Degrees of Freedom	1
Significance Level	0.05
Observed Chi-square	3.71

The theoretical chi-square statistic for the cross tabulation is 3.84 and the significance level is 0.05. The calculated “observed” chi-square is 3.71, lower than the theoretical. Therefore, although the observed chi-square is very close to the theoretical chi-square for a 0.05 significance level, because it is smaller than the theoretical chi square, the relationship is not statistically significant.

Although the relationship between the markers and signs helping and the difficulty getting in and out of businesses is not statistically significant, the survey results show that most people believe the devices made it easier for them to access businesses. Of those who noticed the signs and blue tubular markers, 78% said they helped improve access.

6.0 CONSIDERATIONS AND OBSERVATIONS

There are issues about the use of the Temporary Business Access signs and blue tubular markers that should be considered when these traffic control devices are used on future projects. The issues are based on the authors' personal observations made during the course of their field work in Sweet Home and in Pleasant Hill in 1999 and 2000.

6.1 SIGN MOUNTING

In Sweet Home and Pleasant Hill, the Temporary Business Access signs were mounted on a Type II (A-frame) barricade; a tripod was also tested in Sweet Home. During the study, some of the signs supports were broken or bent, perhaps because they were frequently moved during construction, or they may have been blown over by the wind, or knocked over by motorists or pedestrians. If used on future projects, a more durable sign support that meets the National Cooperative Highway Research Program (NCHRP) 350 crash testing requirements should be used instead of the tripod or Type II barricade. The sign supports should also elevate the sign at least one foot above the ground, as required by the Manual of Uniform Traffic Control Devices (MUTCD).

6.2 CONSISTENCY IN SIGN AND MARKER USE

A second issue was consistency in the use of the Temporary Business Access signs and blue tubular markers. During the course of construction, there were instances where construction affected the business access, yet no signs were put in place. Since the use of the signs was a new requirement for the contractor, their placement was not an automatic part of their routine. There were times when the contractor needed to be advised on when and where to place signs.

Another problem was the visibility of the signs. At some locations, no matter where the sign was placed, it was very hard to see the signs (especially if left hand turns were required to enter the business). Nighttime visibility was also a concern.

Some of the blue tubular markers were also damaged, knocked down, or lost during the course of the construction. On occasion, there were times when the damaged tubular markers were left on site and not repaired or replaced the same day. Again, the use of the tubular markers and signs was a new task for the contractor, and daily inspection of these devices by the contractor did not appear to be a regular part of their routine. It is expected, as tubular markers and business access signs are used in more ODOT contracts, the familiarity and knowledge among contractors about their use will increase.

There was also, for some motorists, a visibility problem with the blue tubular markers. As presented in Section 5.2.2.1, 37% (140) of those surveyed (381) did not notice the blue tubular markers and signs. The authors observed that after the road surface was paved, the blue tubular

markers became harder to distinguish, as their darker color blended in with the new asphalt. One possible alternative to improve contrast, is to use alternating white and blue bands (two each) of reflective sheeting near the top of the tubular marker. This would provide added contrast to the tubular marker during daylight hours, while still distinguishing the blue tubular markers from the orange markers at night.

6.3 USE OF BOTH MARKERS AND SIGNS

Thirdly, as noted in Section 3.2.1, in Sweet Home the decision was made not to use blue tubular markers in conjunction with the signs because of the nature of construction. However, there were instances, based on the authors' opinion, where blue tubular markers could have been used to better delineate the access into a business. For instance, when a temporary work zone was established near a multi-use retail site that was about 100 m in length, orange tubular markers were used to designate the work zone and Temporary Business Access signs marked the entrances. In this circumstance, the use of blue tubular markers at each driveway within the work zone could have been helpful to motorists.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The use of Temporary Business Access signs in Sweet Home and blue tubular markers and Temporary Business Access signs in Pleasant Hill was a positive step in mitigating impacts to businesses during highway construction. The following discussion summarizes the findings regarding the use of these devices on each of the projects.

7.1.1 Sweet Home WCL - Foster Dam Rd. Section

The analysis of traffic count data taken at business accesses in Sweet Home yielded inconclusive results. Seven-day traffic counts were obtained for ten business sites before and during construction (April 1999 to October 1999). Temporary Business Access signs were used while business sites had their driveways reconstructed. Six of the sites experienced decreases in traffic counts during construction. Alternatively, three of the other four sites showed dramatic increases of over 20% or more. Overall, for all ten business sites, the average week-long traffic counts made during construction using the signs was 4.2% less than the average counts taken when no construction activity was present. Though the data indicates a slight decrease in counts with the presence of the signs, because of the limited number of counts made, the effectiveness of the signs could not be determined from this data. Other factors affecting the counts that could not be specifically measured include seasonal variations in traffic and the activities of individual businesses that generated increased customer traffic.

The business and motorist survey data demonstrated the usefulness of the Temporary Business Access signs. When the businesses in Sweet Home were surveyed, 12 of 14 (86%) said the presence of the Temporary Business Access signs helped customers locate the driveways to their business. In the motorist survey, 79% of the 371 people surveyed noticed the Temporary Business Access signs during construction. Additionally, of those who noticed the signs, 83% (242) indicated the signs helped them locate the business access.

There were also comments from the survey respondents about the business access signs. Several people felt the signs should be bigger and placed so they are more visible to both directions of traffic. There was also some confusion with the wording on the sign, "Temporary Business Access." Since the signs were often used at the regular business entrances, the use of the word "temporary" confused some customers.

7.1.2 Goshen - Pheasant Lane Section

The traffic count data for four business sites in Pleasant Hill provided evidence that business traffic was not significantly impacted when blue tubular markers and Temporary Business Access signs were used during periods of construction activity at business accesses. The 7-day

counts, recorded between April 1999 and October 2000, demonstrated a seasonal pattern at each site . The traffic counts were higher in the summer months and lower during the winter, but did not vary significantly between “no construction” and “during construction with signs and markers.”

In the survey of the businesses in Pleasant Hill, 6 of the 12 businesses that had blue tubular markers and signs placed at their accesses, said the devices helped their customers locate the driveways. Four of the business owners said the blue tubular markers and signs did not help, and two owners did not have an opinion.

There were 381 motorists surveyed who live along the OR Route 58 corridor between Goshen and Oakridge. Only 16% (61) of the motorists said that they had trouble getting into and out of any business in Pleasant Hill because of the construction. A substantial number of respondents (315) did not have any difficulty getting into and out of businesses. When people were asked if they noticed the blue tubular markers and Temporary Business Access signs, almost 62% (237) of those surveyed replied they had noticed them. Alternatively, 37% did not notice the devices. Possible reasons for not noticing them could be the size of the sign and its mounting height, and the lack of a contrasting color on the blue tubular marker. Of the 62% who noticed the markers and signs, 78% (185) felt these devices helped them locate the driveways to the businesses.

Were the blue tubular markers and signs the reason a large majority of people had no trouble accessing businesses? The answer could not be determined from an analysis of the motorists’ survey results. A statistical relationship was not confirmed in a cross tabulation of responses to questions about the blue tubular markers and signs helping and the difficulty getting into and out of businesses. Pleasant Hill is a relatively small community and the businesses are spread out more than in a typical setting (like in Sweet Home). Therefore, although the majority of respondents believed they were helped by the blue tubular markers and signs, the low percentage of people who experienced difficulty in accessing businesses could be attributed to less congestion and fewer traffic conflicts in Pleasant Hill.

7.2 RECOMMENDATIONS

Based on the results of this research, the following recommendations are made:

1. On future ODOT projects where business accesses are affected by construction, Business Access signs should be used.
2. Blue tubular markers should be used in conjunction with the Business Access signs even when only a few orange tubular markers are used at the same time in the work zone.
3. The wording on the Temporary Business Access sign should be changed to “Business Access.”
4. The size of the Business Access signs should be increased to be more prominent and visible to motorists.

5. The sign supports for Business Access signs should be durable enough to withstand the rigors of construction and relocation, and meet NCHRP 350 and MUTCD requirements.
6. Instead of using two bands of high intensity blue reflective sheeting on the blue tubular marker, four alternating bands of white and blue high intensity reflective sheeting should be used. The bands should be 75 mm wide and the spacing in between bands should be about 25 mm. The bands of sheeting should be attached so the uppermost band is no more than 50 mm from the top of the tubular marker.
7. A public awareness program regarding Business Access signs and tubular markers needs to be established.
8. Contractors responsible for traffic control at business accesses need to fully understand their requirements for placing, monitoring, and relocating signs and tubular markers at business accesses.

8.0 REFERENCES

De Solminihaç, Hernan E., and Robert Harrison. *Analyzing Effects of Highway Rehabilitation on Businesses*. Transportation Research Record 1395, TRB, National Research Council, Washington, D.C., 1993, pp. 137-143.

Harrison, Robert, and Benjamin Waldman. *Mitigating the Adverse Impacts of the Dallas North Central Expressway Construction on Businesses*. Transportation Research Record 1632, TRB, National Research Council, Washington, D.C., 1998, pp. 51-58.

Ogden, Michael A., Katie Womack, and John M. Mounce. *Motorist Comprehension of Signing Applied in Urban Arterial Work Zones*. Transportation Research Record 1281, TRB, National Research Council, Washington, D.C., 1990, pp. 127-135.

Wildenthal, Marie T., and Jesse L. Buffington. *Estimated Construction Period Impacts of Widening State Highway 21 in Caldwell, Texas*. Transportation Research Record 1559, TRB, National Research Council, Washington, D.C., 1996, pp. 76-83.

APPENDIX A

Sweet Home Business Survey Questionnaire

BUSINESS SURVEY – SWEET HOME

Hello. This is _____ calling from the University of Oregon Survey Research Laboratory. The Oregon Department of Transportation (ODOT) has asked us to conduct a ___ minute survey of businesses in Sweet Home that are located near the construction on Highway 20. I want to assure you that I am not selling a thing, and that this survey is completely confidential and voluntary. The survey results will be used by ODOT to help them improve accesses to businesses during construction on future highway projects. May I please speak with the owner or manager of your business? (Repeat introduction if not manager/owner). Do you have any questions about the survey before we begin?

- 1) How has the construction impacted your business?

Open-ended

- 2) Do you feel that customers are having a difficult time locating the entrance to your business because of the construction?

1. YES
2. NO

- 3) Do you feel that customers are having a hard time parking at your business because of the construction?

1. YES
2. NO

- 4) Do you feel that customers are not stopping at your business because of reduced access caused by construction?

1. YES
2. NO

- 5) Do you think that ODOT could be doing more to help provide better access to your business?

1. YES (GO TO 6)
2. NO (GO TO 7)

- 6) What could ODOT do to help provide better access to your business?

OPEN-ENDED

7) Do you understand what ODOT is doing to reconstruct Highway 20 through Sweet Home?

1. Yes (GO TO 8)
2. No (GO TO 9)

8) Is the construction impact on your business reasonable for the size and complexity of the project?

1. YES
2. NO

9) Have you had blue signs indicating “Temporary Business Access” placed in front of one of your driveways during the construction?

1. Yes (GO TO 10)
2. No (GO TO 11)

10) Do you feel the blue Temporary Business Access signs have helped customers locate the driveways to your business?

1. YES
2. NO

11) May we identify your business in reporting this information back to ODOT (Oregon Department of Transportation)?

1. YES
2. NO (GO TO END)

12) What is your business name?

OPEN-ENDED

END: That is the end of the survey, on behalf of ODOT I would like to thank you for your time.

APPENDIX B

Sweet Home Motorist Survey Questionnaire

MOTORIST SURVEY – SWEET HOME

Hello. This is _____ calling from the University of Oregon Survey Research Laboratory. The Oregon Department of Transportation (ODOT) has asked us to conduct a ____ minute survey of adults age 18 and older who live in the Sweet Home area. The survey results will be used by ODOT to help them improve accesses to businesses during construction on future highway projects. I want to assure you that I am not selling a thing, and that this survey is completely anonymous and voluntary. Please do not even tell me your name. Do you have any questions about the survey before we begin?

1) Are you aware that Highway 20 is being reconstructed through Sweet Home?

1. YES
2. NO

2) Have you driven through Sweet Home in the last _____ weeks?

1. YES (GO TO 3)
2. NO (GO TO END)

3) Approximately how many times have you driven through the highway construction area in Sweet Home?

OPEN-ENDED

4) Have you had difficulty getting into or out of any business in Sweet Home (trouble using businesses because of the construction)?

1. YES (GO TO 5)
2. NO GO TO 6)

5) What was that difficulty?

OPEN-ENDED

6) Do you understand what ODOT is doing to reconstruct Highway 20 through Sweet Home?

1. YES (GO TO 7)
2. NO (GOT TO 8)

7). Do you feel the impact the construction has had on the ability to access (get to and from) the business you use reasonable for the size and complexity of the project?

1. YES
2. NO

8) Have you noticed the blue signs indicating “Temporary Business Access” placed in front of the driveways to businesses during the construction?

1. Yes (GO TO 9)
2. No (GO TO 10)

9) Do you feel the blue Temporary Business Access signs have helped customers including yourself locate the driveways to businesses?

1. YES
2. NO

10) Do you feel that ODOT (Oregon Department of Transportation) could be doing more to help businesses with customer access during the highway construction?

1. YES (GO TO 11)
2. NO (GO TO END)

11) What do you think ODOT could do to help customer access to the businesses during construction?

OPEN-ENDED

END: That is the end of the survey, on behalf of ODOT I would like to thank you for your time.

APPENDIX C

Pleasant Hill Business Survey Questionnaire

BUSINESS SURVEY – Pleasant Hill

Hello. This is _____ calling from the University of Oregon Survey Research Laboratory. The Oregon Department of Transportation (ODOT) has asked us to conduct a 5-minute survey of businesses in Pleasant Hill that are located near the construction on Highway 58. I want to assure you that I am not selling a thing, and that this survey is completely confidential and voluntary. The survey results will be used by ODOT to help them improve accesses to businesses during construction on future highway projects. May I please speak with the owner or manager of your business? (Repeat introduction if not manager/owner). Do you have any questions about the survey before we begin?

1) Prior to construction, did you have any contact with ODOT about the project?

1. YES
2. NO

2) Did the Oregon Department of Transportation address your concerns about the construction on Hwy 58?

1. YES
2. NO

3) How has the construction impacted your business?

OPEN-ENDED

4) Do you feel that customers are not stopping at your business because of the reduced access to your business caused by construction?

1. YES
2. NO

5) Do you feel that customers are not stopping at your business because of other reasons as a result of construction.

1. YES SPECIFY: What are those?
2. NO

6) Do you think that ODOT could be doing more to help provide better access to your business?

1. YES (GO TO 7)
2. NO (GO TO 8)

7) What could ODOT do to help provide better access to your business?

OPEN-ENDED

8) Is the construction impact on your business reasonable for the size and complexity of the project?

1. YES
2. NO

9) Have you had blue tubular markers (cones) and blue signs indicating “Temporary Business Access” placed in front of one or more of the driveways to your business during the construction?

1. Yes (GO TO 10)
2. No (GO TO 11)

10) Do you feel the blue tubular markers and Temporary Business Access signs have helped customers locate the driveways to your business?

1. YES
2. NO

11) May we identify your business in reporting this information back to ODOT (Oregon Department of Transportation)?

1. YES
2. NO (GO TO END)

12) What is your business name?

OPEN-ENDED

END: That is the end of the survey, on behalf of ODOT I would like to thank you for your time.

APPENDIX D

Highway 58 Corridor Resident Survey Questionnaire

RESIDENT SURVEY – Highway 58 Corridor

Hello. This is _____ calling from the University of Oregon Survey Research Laboratory. The Oregon Department of Transportation (ODOT) has asked us to conduct a ___ minute survey of adults age 18 and older who live near Highway 58. The survey results will be used by ODOT to help them improve accesses to businesses during construction on future highway projects. The survey is completely voluntary and anonymous. Please do not even tell me your name. Do you have any questions about the survey before we begin?

1) Are you aware that Highway 58 is being reconstructed through Pleasant Hill?

1. YES
2. NO

2) Have you driven through Pleasant Hill in the last 2 months?

1. YES (GO TO 3)
2. NO (GO TO END)

3) Approximately how many times have you driven through the highway construction area in Pleasant Hill?

OPEN-ENDED

4) Have you had difficulty getting into or out of any business in Pleasant Hill (trouble using businesses because of the construction)?

1. YES (GO TO 5)
2. NO GO TO 6)

5) What was that difficulty?

OPEN-ENDED

6). Is the construction impact to Pleasant Hill Businesses reasonable for the size and complexity of the project?

1. YES
2. NO

7) Have you noticed the blue tubular markers (cones) and blue signs indicating “Temporary Business Access” placed in front of the driveways to businesses during the construction?

1. Yes (GO TO 8)
2. No (GO TO 9)

8) Do you feel the blue tubular markers (cones) and blue Temporary Business Access signs have helped customers including yourself locate the driveways to businesses?

1. YES
2. NO

9) Do you feel that ODOT (Oregon Department of Transportation) could be doing more to help businesses with customer access during the highway construction?

1. YES (GO TO 10)
2. NO (GO TO END)

10) What do you think ODOT could do to help customer access to the businesses during construction?

OPEN-ENDED

END: That is the end of the survey, on behalf of ODOT I would like to thank you for your time.